first national conference on wheat utilization research

Held October 29-31, 1962 at Lincoln, Nebraska

The FIRST NATIONAL CONFERENCE ON WHEAT UTILIZATION RESEARCH was held in Lincoln, Nebraska, at the Nebraska Center for Continuing Education, October 29 to 31, 1962. Organizations and personnel responsible for program and arrangements are mentioned in the first speech, presented by Mr. Howard Morton (page 3).

The objectives and long-range hopes for the series of annual conferences beginning with this one were expressed in numerous comments and deserve an effort toward summarization. All segments of the wheat industry--growers, millers, bakers, and export and domestic marketers, as well as research workers whose studies bear on these various areas--met and will continue to meet in the utilization research conferences. Thus the entire wheat industry becomes an intact, coordinated, problem-solving organization. This broad concept of utilization research and development in agriculture is new and virile and promises continuous reduction of the major problems in this largest of all American agricultural industries. It is the confident expectation of all concerned that these hopes will be fully realized.

The Second National Conference on Wheat Utilization Research will be held at the Northern Regional Research Laboratory, U. S. Department of Agriculture, Peoria, Illinois in the later months of 1963.

This report was prepared in the Western Regional Research Laboratory, Albany 10, California--headquarters of the Western Utilization Research and Development Division of the Department's Agricultural Research Service. Copies are available on request. In addition, copies of a report of the conference held earlier in Albany, Calif. on the "Role of Wheat in the World's Food Supply" are available to those interested.

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REPORT OF CONFERENCE ON WHEAT UTILIZATION RESEARCH

THE INITIATION AND ORGANIZATION OF THE CONFERENCE

Howard Morton
Director of Utilization Research, Great Plains Wheat, Inc.

Ladies and Gentlemen: It is my pleasure at this first session to introduce the NATIONAL WHEAT UTILIZATION RESEARCH CONFERENCE. The advanced planning has been highly informal and conducted with enthusiastic support of the National Association of Wheat Growers; the Western and Northern Regional Utilization Research Laboratories and other participating agencies of the U. S. Department of Agriculture; our Nebraska hosts, the Wheat Commission, the Wheat Growers, and the State Experiment Station; Western Wheat Associates; and Great Plains Wheat, Inc., whose Utilization Committee I represent. As Chairman of the Program Committee, I would like to thank those who worked with me in developing the program, including Dr. M. J. Copley, Director of the Western Utilization Research and Development Division, USDA; Dr. Fred Senti, Director of the Northern Utilization Research Laboratory, USDA; Dr. H. H. Kramer, Director of the Agricultural Experiment Station, Nebraska University; Paul Mattern, Nebraska Agricultural Experiment Station; Dr. Mark Barmore, Agricultural Research Service, Washington State University; and especially Robert L. Olson, USDA, Western Utilization Research Laboratory, who has served as Secretary of the Committee and has worked so diligently to make the Conference a success. I would also like to express my deep appreciation to Dr. James Pence and Dr. George Kohler of the Western laboratory and Mr. Cap Mast of the Millers National Federation for their efforts in making the Conference possible.

I also want to congratulate Dr. Kramer's local Arrangements Committee, who has organized the local facilities here at Lincoln, and who has created such public interest by effective announcements. Pearle F. Finigan, Nebraska Director of Agriculture; C. H. Kreader, Secretary of the Nebraska Wheat Growers Association; Robert Florell, Nebraska Center for Continuing Education; Robert Puelz, Manager of Equity Union Grain Company; and Jim Albracht, Chief of the Nebraska Wheat Commission, served on Dr. Kramer's Committee. Bob Florell's interest and enthusiasm I am certain are in a large way responsible for the excellence of the arrangements. I am expressing the gratitude of us all when I offer him my sincere thanks.

The informal structure upon which this meeting has been organized will continue and annual meetings on this subject are anticipated. Because these meetings are national in scope and serve the entire wheat industry, it will be appropriate for the location of the meeting to be moved from year to year. This will provide for local participation in the major wheat producing areas as subsequent meetings are held. The Program Committee welcomes suggestions and volunteer help. Please come to me or representatives of the sponsoring groups with your comments or questions during the course of the meeting.

In the few minutes allotted me, I intend to discuss agricultural research and factors that have led to the initiation of meetings on wheat utilization research. The function and importance of utilization research will be discussed in greater detail by Dr. Maclay and its direct applications to wheat by Dr. Matchett later in the program.

What has research done for agriculture? Research has provided new varieties with higher yields and disease resistance as well as chemical fertilizers, insecticides, and herbicides. It has adapted machines to farm use, replacing the horse. It has provided information on the interdependent relationships of soil, water, fertilizer, season, variety, pests, and agronomic skill needed to increase crop yield. Research assures our capacity to produce the food and fiber we need. Research has provided new processes and products that widen our markets and improve our living standards.

Research has so improved the efficiency of farming that food and fiber for 26 people are produced by each farm worker now, compared with only 5 people one hundred years ago. One result of the improved farm efficiency is that the decreasing number of us who remain on the farm have witnessed growing numbers of our neighbors and their children moving into the cities. While we feed and clothe them, they produce the materials of comfort and culture and the technical advances that lengthen our lives and make our years more enjoyable. So swift has been this advance that, as a national enterprise, we need only about one-twelfth of our labor force for food and fiber production. The freeing of this tremendous potential for nonagricultural productivity is an accomplishment of agriculture and is based on research.

Research throughout the years has been conducted by Federal and State institutions, corporations, and individuals. The findings of research have been made widely available by Federal and State extension services and also by the manufacturers of farm equipment and other agricultural suppliers. The applications of research have been made by the farmers of the nation, with such results that the cost of producing food for the nation is estimated as being 15 billion dollars less each year than it would have been if we were now farming as we did only a short 25 years ago. The advance of our society depends on continuing agricultural research. The point of no return has passed. Research is the prime mover of agriculture, as well as any other technical progress.

A hundred years ago, Congress and Abraham Lincoln's administration initiated Federal and State research on a firm basis. (All publicly supported research in those days was agricultural. Now agricultural research is dwarfed by military, space, atomic energy, and public health research.) A compelling factor in the origin of public sponsorship of research was the recognition that individual farmers had not the financial strength to capitalize research that was desperately needed and would be beneficial to the entire nation by improving farm efficiency and increasing knowledge. I believe the few statistics I recited here today do bear witness to the success of such a concept.

Farm value of food produced now is about 30 billion dollars per year. We are acutely aware that farm value does not reflect the major cost of food to consumers. About one and two-thirds times the farm value is added to reach

retail food cost. Fifty billion dollars a year represent the cost of shipping, processing, and distributing food, including the attendant profits. Much of the processing is conducted by relatively small packers and individuals who cannot adequately capitalize the research; nor can they withstand the economic pressure of paying for research that will, if successful, provide equal benefits to competitors who have borne no such costs. Yet the potential benefits of research in this area are improved efficiency and new and better products for the entire populace, the continuing enlargement of our markets at home and abroad, and the stimulation of our tremendous potential for production. Again, State and Federal sponsorship of research is justified and is being conducted along with non-public research in this area.

Some of us believe there is too little utilization research. Research conducted to improve utilization of our farm products should be developed to its maximum strength, and this brings us to the object of our meeting. This and subsequent meetings will serve as a forum for the varied interests in WHEAT UTILIZATION and can create additional opportunities to produce, handle, process and merchandise.

At this meeting an exchange of ideas, problems, and answers is anticipated. An important part of the idea exchange will be among the scientists. Those who are separated by geography and fields of interest can benefit by the first-person exchange of ideas and can better develop a coordinated attack on problems from their varied disciplines. And all of us can develop a better understanding of interdependent relationships of research in production, utilization, and marketing by participation in the discourses to be conducted here the next three days.

It is an old and wise saying that research reveals more questions than answers. But never forget that each answer uncovered is a step forward and each new question creates a new opportunity. I am pleased to participate in the National Wheat Utilization Research Conferences. Here this week, and in subsequent meetings, I'm certain we will witness important revelations. I trust that you, who have shown your interest by being here, will find the meeting rewarding and will lend this venture your support wholeheartedly, now and in the future.

THE IMPORTANCE OF UTILIZATION RESEARCH

W. D. Maclay
Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

I'm always glad to meet with "wheat" people because of the high priority of this cereal grain and its products in the USDA utilization research program; because of the fine relationships between our personnel and the many segments of the wheat producing, marketing, processing and baking industries; and because of a firm belief that with an imaginative, coordinated, and vigorous research attack on the many facets of the so-called "wheat problem," definite contributions can be made toward its solution.

Since succeeding speakers will discuss many phases of wheat utilization, I shall confine my remarks to the broader aspects of utilization research and development. In agriculture, the search for new and extended uses for farm raw materials has come to be called utilization research.

Utilization research is to the farmer what industrial research is to industry. It is aimed at expanding markets for agricultural commodities through development of new and improved products for food and industrial uses. This means providing consumers with more attractive and desirable products--better quality, greater variety and convenience, at lower cost. It is an effective instrument in achieving balance between production and the economic use of agricultural commodities. It contributes to better, more stable farm income and more efficient use of our agricultural resources.

<u>Utilization research and the farmer</u>. Agriculture in America--supported by a century of research as well as by the sweat of farmers for centuries earlier--has done remarkably well in the past several decades, compared to agricultural progress anywhere else in the world. But in spite of our farmers' great productive capacity and the progressiveness of American agriculture, much remains to be done if we are to make the best use of our agricultural resources. Our per capita land use for agriculture is the highest of any nation on earth. We fail to use land more efficiently because we fail to exercise fully known conservation measures and to develop better ones fast enough. We waste water because we haven't learned how best to apply or conserve it. We waste the productive capacity of land, water, fertilizers, chemicals, and manpower by raising quantities of crops for which we have no markets. We waste surplus crops because we have been unable to develop products which will provide adequate, profitable markets for our annual overproduction.

Some of the obstacles to improvement in each of these problem areas can be removed by wider application of knowledge we now have. Most of them, however, pose questions for which we have no answers. This means research in all areas of agriculture--<u>production</u>, <u>utilization</u>, <u>marketing</u>, and <u>home economics</u>--and <u>all kinds of research</u>, <u>basic</u>, <u>applied</u>, and <u>developmental</u>.

Utilization research, in creating larger markets for the things the farmer grows, has an important role in assuring more efficient use of our agricultural production. But utilization research cannot operate alone. It is essential that production and marketing research approach unsolved problems hand in hand with utilization research if we are to succeed. Perhaps the greatest obstacle to the development of wider industrial uses for farm products is their tendency to vary in price, supply, and quality as raw materials. Both production and marketing researches are necessary to meet and remove these obstacles. All this research is geared to enable the farmer to produce, with a fair return for his labor and capital, a steady supply of raw materials having the properties and quality required by, and prices that are attractive to, the processing industries.

Utilization research and the consumer. Utilization research serves the consumer in all three of the major uses to which agricultural products are put: First in food: 3/4 of a ton a year for each of us. Second in clothing: use of cotton, wool, and leather totals about 30 pounds per person per year. Third in a myriad of "industrial" items: products like paints, plastics, adhesives, lubricants and detergents which are usually compounded from several source materials, making estimates of per capita raw material consumption difficult. In all three areas, utilization research, to be successful in its objectives of expanding markets for farm products, must find ways to produce products the consumer desires. If the ultimate consumer does not receive benefits in higher quality, availability, convenience, or price, he will not purchase the product.

This ceaseless competition for the consumer's dollar motivates research to develop new or better products, whether they are products derived from petroleum, "coal, air, and water," or from forest and farm commodities. In clothing, and in those other uses which we call "industrial"--fuels, fibers, plastics, lubricants, adhesives, and the like--utilization research in agriculture is in direct competition with the tremendous research operations of corporations that create consumer goods from nonfarm commodities. Agriculture does have allies, of course, in the research laboratories of those companies that process farm products, but most of industry feels no obligation to risk its own resources in searching for ways to use more farm products as raw materials in their operations. The textile, shoe, and detergent industries are good examples. If the consumer's criteria for preference are better met by products made from petroleum than from cotton, wool, leather, and animal fats, companies will move away from the farm products or lose their business to companies that do.

The service of utilization research to the consumer is just as important in the food field as it is in industrial products, but there are marked differences. There is now no serious competition in food production from nonfarm sources; only a few specialties such as sweetening, flavoring, and coloring agents, preservatives, and vitamins, are synthesized. It is not probable that practical synthetic processes will be developed for major foods in the foreseeable future.

But there is competition between farm commodities for the consumer's food dollar. All of our food products compete both with other foods of the

same type--beef with pork, broccoli with cauliflower with beans, apples with peaches--and each with themselves in various forms. Fresh vegetables and fruits compete with canned, frozen, and dried, and for a share of the prepared food market.

A major desire of consumers today is for convenience in food products--what has been called "built-in maid service." Time is important to the modern housewife, whether she works outside the home for pay or within it to raise a family. The result of this desire for ready-to-use foods is evident in the grocery, in the home, and in the utilization research programs, both public and private, that have made them possible.

Utilization research and process development in agriculture serve the consumer by giving him the products he desires, and the farmer by providing markets for his crops. But it has been said that if one really serves the consumer's interests, he attempts to produce better or cheaper goods, without worry about the farmer or miner or oil driller or any particular supplier of raw material. Leaving out considerations of general welfare, this statement is reasonable. However, it in no way conflicts with the major premise that agricultural utilization research, indeed any agricultural research, can only serve the farmer by satisfying the desires of consumers.

Bridging the gap between producer and consumer. The processor and the distributor are essential links between the producer and the consumer. The agricultural producer, operating in a domestic industrial economy in which prices of most of the things he has to buy have risen much faster in recent years than prices he has received, and operating also in a foreign market presenting many difficulties, must be extremely efficient in order to obtain profits while producing raw materials that assure ever larger consumer purchases. This status for the farmer can only be attained and maintained by making available to the consumer those products of composition, utility, attractiveness, convenience, availability, and cost that will encourage greater consumption. That the farmer can produce an abundance in excess of our current and immediately foreseeable future needs is an accepted fact. His biggest problem is to produce at a unit cost that will make his products both desirable and profitable to use as food and for industrial uses in a greater total amount. This is a job for both the farmer and the processor, aided by utilization research. Let's take a look at a few ways in which utilization research has helped in this regard.

Food products. The trend during the last two decades has been away from kitchen drudgery. The housewife no longer has time or inclination to pluck chickens, squeeze oranges, or even to peel potatoes. She likes prepared foods of high quality that are convenient to use. It has been repeatedly demonstrated that if these criteria are met she will buy in quanitity--sufficient to change the whole aspect of an industry and to increase overall consumption of a crop. Frozen orange juice concentrate is a striking example. Ready-to-eat or ready-to-cook chicken and turkey products have revolutionized the distribution of poultry. The processing of dehydrated mashed potatoes and frozen French fries is growing vigorously. These are typical examples of a whole host of food products--improved frozen fruits and vegetables; frozen bread and bakery products; fruit and vegetable juice powders; fruit flavor

essences; improved egg solids; fresh-pack pickles; high-quality soybean and cottonseed oils; quick-cooking rice and beans. These have been developed with built-in quality and convenience that have contributed and will continue to contribute greatly to expansion of markets.

Industrial products. Vigorous and imaginative industrial research, spurred by our needs in the first World War, has since brought this country more of the things associated with good living than were ever known before. Industry's quest for raw materials adapted to processing and stable quality, supply, and price has turned it increasingly to petroleum and coal, in many cases at the expense of agricultural raw materials. Synthetic detergents now command over half the soap market which once absorbed agricultural inedible fats; plastics have replaced leather in a major portion of the shoe market and in other applications as well; synthetic and man-made fibers having specific advantages are making great inroads in cotton and wool markets.

Utilization research in recent years has demonstrated that lost markets can be regained and new and better ones developed. Through improved processing and chemical or physical modification, farm products can be given properties that match those of many of the synthetics. It has been shown that cotton and wool fabrics can be endowed with wash-and-wear qualities; cotton can be made to resist weather and rot; fat can be transformed to practical plasticizer-stabilizers, to new and better surface coatings, even to improved detergents; wool can be shrink-proofed and the wastes from its processing recovered and used; fermentation can convert grain to new and more efficient feeds and supplements, to organic acids and other raw materials for the chemical industries; starches can be used in paper and textile making.

A look at the future. The development of broad new outlets for farm products which will contribute to balance between their production and utilization, in such a manner that all segments--producer, processor, distributor, consumer--are equitably treated, is the principal objective of utilization research. To develop and sustain an effective attack on this vexing problem will require increasing care in the selection and evaluation of researches to be undertaken. Analyses of relevant scientific advances, technological developments, market opportunities, economic climate, and new consumer and end-use requirements will have to be made continually to keep new-product research and development dynamic and realistic.

Research on foods and feeds. Development of new and better food products, food processing methods, and improved feedstuffs, upon which the production of our essential animal food products depends, must be integral parts of an effective research program directed toward increasing use of our farm crops. Strong currents of change are running in the eating habits of Americans. The evident trend toward a lower average per capita caloric intake, the strong appeal of "convenience" products that are available nationally and the year around in dependable high quality, the opposite trends in the usage of fruits and vegetables, meat, milk, and poultry products, on the one hand, and of cereal products, dry beans, and sweet potatoes, on the other--all of these create a competitive situation between groups of farmers which has important national implications. In the present state of our knowledge, the adverse trends in the consumption of some commodities will continue. But scientific

and technological developments constitute a force which makes every prediction based on trends provisional, and the downward trend in the usage of some of our farm products is no more than a reflection of our ignorance of their true usefulness. Witness the reversal of the 50-year decrease in the use of potatoes. We would be remiss in our obligations to producers of a commodity if we permitted a disastrous shrinkage in demand to occur merely because our knowledge of true utility remained obscure or superficial.

Total grain consumption would be increased if a larger proportion of our cereal grain harvest were converted into animal products. When we eat a pound of pork we consume 6 pounds of grain; a 3-pound fryer embodies 7 to 8 pounds of feed; a pound of beef represents not only several pounds of feed grain, but pasture as well. Development of new and improved feedstuffs is linked directly to the economy of animal products.

Competition between foods for the housewife's dollar will encourage---yes, even require--the development of attractive and convenient new foods at reduced costs to increase consumption of any particular commodity. The development of stable and attractive new foods is a complex undertaking involving many and varied professional skills. Extensive fundamental research is required to disclose the chemical constituents and the physical makeup which govern the color, flavor, texture, and nutritive value of our commodities. With essential information on their character we will be able to better protect the fine qualities we wish to preserve while avoiding or rejecting unwanted ones and thus produce foods essential to the best health for all segments and ages of our population in the modern pattern of better living in the twentieth century.

Industrial products and processes. Great possibilities of expanded use lie waiting in the field of new industrial products. The complex carbohydrates, proteins, fats, and minor constituents of our farm crops have characteristics which differ from those of any other raw materials. Advantage can be taken of them in the manufacture of economic products that differ from any now on the market and that cannot be prepared from other raw materials at lesser cost.

In the industrial field, three industries--chemical, paper and flexible film, and textile--hold high potential for expanded uses for farm products. The chemical industry's production exceeds 15 billion pounds annually. Its products are sold to every section of American industry. Its more important end products are fibers, surface coatings, plastics and resins, surface-active agents, fertilizers, rubbers, medicinals, pigments, antiknock agents, explosives, solvents, printing inks, pesticides, catalysts, dyes, antifreezes, adhesives, plasticizers, lubricating oil additives, rubber processing chemicals, bleaches, antioxidants, wood preservatives, adsorbents, flavor agents, synthetic lubricants and hydraulic fluids, photographic chemicals, gasoline additives, refrigerants, perfume chemicals, aerosol propellants, water-soluble gums, paint driers, and flotation agents.

Nearly half a billion dollars worth of agricultural products (principally starch, linseed, soybean, and tung oils, soybean meal, tallow, blood, and animal glue, and cotton linters) are used annually by the chemical

industry. If this amount is to be greatly increased, advantage must be taken of the natural structural and polymeric properties of agricultural commodities to derive wholly new and better products than are now on the market. From a technical point of view, the following segments of the chemical industry offer the greatest potential for utilization research: plastics and resins, synthetic rubbers, plasticizers, and surface-active agents.

The paper industry constitutes one of the important large-volume industrial outlets for organic chemicals derived from domestic crop and livestock products. In 1959, 34 million tons of paper and board were produced in the United States. About 691,000 tons of cereal starch, resin, animal glue, soybean protein, and other chemicals of domestic farm origin, plus 244,000 tons of directly competing imported crop and livestock derivatives, were required to process this quantity of paper.

It is estimated that paper and board production by U. S. manufacturers will reach 58 million tons in 1975. If one assumes only continuation of the 1959 ratio of paper and board production and consumption of organic chemicals, a total market of 1,600,000 tons of processing chemicals will be promoted by this industry. Another promising approach is the recent finding that starch can be chemically combined with wood fiber up to 50 percent by weight, and the resulting papers exhibit higher values for most of the important properties of paper than the untreated controls.

Expansion of flexible transparent film product even greater than that for paper is predicted in the years ahead and should provide an excellent outlet for the linear-chain-amylose starch now well along in development from high amylose corn. Not only does our domestic textile industry use nearly 9 million bales of cotton and some 500 million pounds of wool annually, but it makes use of enormous quantities of starch and other chemicals, both agricultural and nonagricultural in origin.

Total fiber production over the past two decades has increased nearly 66 percent as compared with a population growth of slightly over 33 percent. Cotton consumption increased almost in step with population growth; wool consumption lagged behind population growth; but the consumption of rayon, acetate, and the noncellulosic synthetics increased much faster than population. There is reason to believe that total textile consumption will continue to increase at a rate more rapid than population over the next five years. Through vigorous research to further improve the properties of cotton and wool, these fibers appear to have a better chance than at any time in the past two decades to share the anticipated textile market gains on equal terms with the synthetics.

World markets. Foreign markets are many, and each has its individual needs. If we can supply a product that is tailored to the needs and wishes of the people at prices competitive with those of other suppliers, outlets for vast quantities of food products can be found. People of foreign lands are like ourselves. They will use their traditional foods freely, and they can be sold new ones that are wholesome and palatable. Examples have been the increased use of U. S. soybeans by the Japanese in their traditional foods and their greatly expanded use of wheat in recent years in the form of leavened

baked goods. To expand foreign markets, it is necessary to study the preferences of the people and the reasons for them. On the basis of such information, new, stable, palatable, and nutritious foods can be developed in conformity with their living styles and standards. With the world's standard of living gradually increasing, expanding foreign markets for our surplus agricultural products should result.

In twenty short years, utilization research--the search for new and extended uses for agricultural raw materials--has earned an important place in agriculture's scientific armamentarium. More and more it will become associated in the public consciousness with the traditional types of agricultural research, as a force for benefiting the farmer and all of us. It is not the whole answer to the surplus problem--but it can and will be an effective contributor to the solution of that problem.

Discussion: A question was asked concerning the possible loss of esthetic quality in the overstandardization of products resulting from the trend in new convenience products. The idea, of course, is to standardize at a very high quality level. However, with a growing cost-price spread competitive pressures will tend to force compromises with quality. Nevertheless, the demand for built-in maid service in processed products is increasing with the increased standard of living. More and more people can afford the cost of convenience and the trend will continue.

REVIEW OF CONFERENCE ON THE
"ROLE OF WHEAT IN THE WORLD'S FOOD SUPPLY"

M. J. Copley
Western Regional Research Laboratory, USDA, Albany, California

The National Association of Wheat Growers, during their meeting at Boise, Idaho, in December of 1961, resolved that a conference be held, aimed at "expanding the use of wheat from our country in meeting the food requirements of the world." As a result, a 3-day conference was held at the Western Regional Research Laboratory in Albany, California, April 30 to May 2 of this year, under the joint sponsorship of the National Association of Wheat Growers, Great Plains Wheat, Inc., Western Wheat Associates, Inc., and participating agencies of the U. S. Department of Agriculture. The subject was, "The Role of Wheat in the World's Food Supply."

It is with genuine pleasure that I address this wheat research conference, and I am happy to see many who were also at the spring meeting. For those who were not privileged to be at the earlier conference, I have been asked to summarize briefly what was accomplished there. For anyone interested in a more detailed account, a complete report of all the speeches is available, which can be obtained upon request to the Western Regional Research Laboratory, Albany 10, California.

This meeting was unique in that it was probably the largest gathering of experts and authorities on all phases of wheat research that has ever been assembled. Much interest was created, and many requests have come in from all over the world for the report of the speeches given and for information concerning the new wheat products described at this meeting.

The first day was devoted to a study of the food-deficient areas of the world, with special consideration to identification of the countries which could develop into the greatest potential markets for our wheat. There is of course no surplus of food in the world. Every day millions of people go to bed hungry. Our problem in reality is not one of surplus but of two lacks--the lack on our part of a way to get our wheat to the people who need it, and a lack on their part of a way to pay for it. It is like the case in algebra where two minuses equal a plus. Instead of spending our time considering how to get rid of the plus, possibly we can obtain better results if we consider how to get rid of the two minuses. For if we could get our food out of the storage bins and into the hands of those who are in need of it, and if they in turn could pay us for it, our surpluses would disappear. A relationship with other nations of mutual respect and benefit would result.

Available information indicates that about three-fifths of the world's population suffer from food shortages. The greatest nutritional gap is found in the Free Far East, where the deficit is calculated as 60 percent; Communist Asia comes next with a deficit of 25 percent. Africa and South America also fall into the seriously food-deficient category. The major

nutrition problem is protein deficiency; it is reported that over 50 percent of the children between the ages of one and four in low-income families in Latin American countries suffer from kwashiorkor and other diseases of protein malnutrition.

The second day of the meeting was devoted to the nutritional values of wheat--just how good a food wheat really is, and what role it could play in eliminating the great nutritional gap which exists in the world. In the last few decades wheat has been steadily losing ground as a food in the USA. This is possibly due to a misconception which has been prevalent concerning the nutritional value of wheat. There are numerous reports in the literature of experiments, mainly carried out on rats and other animals, which indicate that wheat protein is deficient in the essential amino acid, lysine. However, there is other evidence around which seems to prove that wheat is a very good food indeed. For instance, the protein deficiency disease, kwashiorkor, which takes such a terrible toll in some countries, is almost unknown in the wheat-eating nations.

Dr. Elsie Widdowson of the University of Cambridge, England, one of the world's most distinguished nutritionists, came to the conference to report some extremely significant tests which were carried out by her and Prof. McCance, also of Cambridge University, in a German orphanage, shortly after World War II. The tests were conducted for a period of one and one-half years on a group of 180 initially undernourished children. They were fed a diet in which 75 percent of the calories were derived from wheat, 21 percent from vegetables, and less than 4 percent from animal protein. Dr. Widdowson and her colleagues found that this diet, supplemented with calcium and vitamins A, D, and C, provided the children with all the nutrients required for a high rate of growth and development, and at the end of the experiment they were on a par with children who had had the best diets obtainable.

Speaking on the nutritional value of wheat, Dr. D. M. Hegsted, of the Harvard School of Public Health, one of the foremost authorities on nutrition in the United States, pointed out that an individual on a diet of wheat alone, sufficient to meet his caloric requirements, would receive more than the minimum requirements of all the essential amino acids, and actually double the minimum requirements of lysine. Wheat is low in calcium and the vitamins A, C, D, and riboflavin; however, all these can easily be added to wheat in processing. Dr. Hegsted stated that "On a theoretical approach it is rather easy to derive a diet, based almost entirely on wheat, which looks reasonably adequate."

Such evidence as was presented by Dr. Widdowson and Dr. Hegsted can hardly be ignored. It was suggested that wheat has appeared to be deficient in lysine in experiments with rats because of their shorter life span and much more rapid growth rate in comparison with humans, so that their need for lysine is actually far greater, thus making the tests in this respect fallible. There is also some evidence, according to Dr. William B. Bradley of the American Institute of Baking that a high cereal intake protects against high blood cholesterol, atherosclerosis, and coronary heart disease. More research could be done and should be done to corroborate these findings and to bring about the recognition of wheat for the fine food that it really is.

The next problem considered was this one: Since there is great need for food in the world, and we have a surplus of an almost ideal food to fill this need, why is it that we cannot sell our wheat or in some cases even give it away? There are various reasons. For instance, four-fifths of the food deficit is in the Far East where rice is the staple diet, and to turn people to the use of wheat would involve changing food habits of long standing. These people are not acquainted with wheat or wheat products, or how to use them. They are unacquainted with bread and do not have the milling facilities to make flour. Since wheat needs some processing to be edible, this is quite a stumbling block. Also they do not have unloading, transportation, and distributional facilities to handle large quantities of wheat. And of course, the greatest reason of all is that they do not have the dollars to buy wheat, and even when we try to give it to impoverished nations, they are sometimes reluctant to take it, because they do not like to become obligated to us and they feel that we may wish to exercise political control over them in exchange for our food.

The Agricultural Trade Development and Assistance Act of 1954, which is also known as P.L. 480 and Food For Peace, has provided a way for us to sell our wheat to countries which do not have dollars to pay for it. We accept the currency of the recipient country, and we use this foreign money to pay for our embassies and to meet other expenses we may have in that country. Much of it is made available to the receiving country in the form of loans and grants for investment in its own economic development. Five percent of the proceeds of P.L. 480 is set aside for use in promoting the sale of our agricultural products. In the last few years this money has been increasingly put to use by our wheat organizations in various promotional activities designed to increase the sale of wheat, such as bakers' training programs, mobile demonstration units to carry on nutritional education, lunch programs for school children, displays, fairs, and exhibits. This is a good use of P.L. 480 money, and it was concluded at the Conference that these activities could be still further expanded with good results. It was predicted also that many countries now buying wheat with soft currencies will eventually develop into dollar markets. This development has taken place in Japan and Italy.

In 1961 our exports of wheat amounted to over 700 million bushels, approximately 70 percent of which went out under government programs; most of this was under Title I of P.L. 480, in exchange for soft currencies. Our main dollar markets are Japan, the Philippines, and Europe. However, there is grave danger that we may lose our European outlet, because of the formation of the Common Market, which may result in a stiffening of trade barriers, and also because of the uncertain quality of our wheat.

The Common Market countries are capable of producing practically all of their wheat needs; however, they have to import strong wheat to blend with their own in order to improve baking quality. Unfortunately for us, they prefer Canadian spring wheat to ours because of its superior strength; also they object to the use of chemical maturing agents such as our winter wheats require. There is urgent need for basic studies on the mechanism of maturing of flour, in order to develop more acceptable means of bringing about rapid maturation without use of chemical additives. The recent USDA appropriation bill carried funds which will enable us to tackle this problem.

I would like to digress here and mention a few other hazards facing wheat. In recent years, while the per capita consumption of bread has failed to increase, the use of sweet rolls, cakes, and cookies has expanded significantly. In contrast to bread, these sweet goods are high in saturated fats. The American Medical Society has recently come out with a warning that such bakery products may be harmful because of their large content of saturated fats, which are alleged to increase the cholesterol content of the blood and thereby become a primary cause of heart disease. The public is very health-conscious, as is shown by the tremendous increase in the sale of unsaturated fats, such as safflower oil, and, in reverse, the disastrous drop in consumption of whole milk and butter. Studies should be initiated to learn how to use unsaturated fats in making bakery products, or we may lose a very lucrative market.

Another problem of utmost importance concerns the use of wheat flour in a variety of refrigerated, frozen, and canned foods. Health agencies, State and Federal, are questioning whether our standard flours are always clean and sterile enough for such uses. A method is needed for sterilizing flours at the processing plant where these products are being manufactured. The volume of such products has been growing rapidly, but wheat flour is being replaced by vegetable starches for which sterilization procedures have been developed, although it is generally agreed that the substitution results in a loss in quality of the product. We also expect to initiate research on this problem during this fiscal year.

There is also the problem of improving the flavor of bread. Many people think commercial breads are deficient in flavor, especially some of the newer types. This is thought to be one of the reasons why the use of bread has been decreasing. Mr. Olson will later discuss this in greater detail; as he will tell you, we are carrying on research designed to solve this problem.

Though there is much research needed in the future, we can also look at what has been accomplished already with a measure of satisfaction. The development of bulgur and methods for its economical production in volume has created a product which will, I believe, open substantial new markets for wheat. Other products are in the process of development, which have great possibilities, such as meat-like and milk-like products, survival wafers, and pearled wheat.

Mr. Clifford Hope said in his address at our first meeting: "With world conditions as they are today, the only program which makes sense on a permanent basis is research directed toward the development of new and improved products and means for introducing them into new markets. Then and then only will there be full opportunity for wheat to play its rightful role in the world's food supply."

I also think, and I believe it was the consensus of the conference, that the wheat industry, although it faces many problems in the future, has cause for satisfaction in that it is making a resolute effort to solve its difficulties by united action, as evidenced by these meetings. In fact, much progress has been made in the last few years. For instance, the wheat disappearance for 1961 was equal to more than a year's harvest. Whereas in the past, great effort was expended on the production of wheat, we have now come to realize

that the wheat industry, like any other industry, must also work at developing new markets and maintaining old ones, must keep a program of research going in order to keep abreast of the times, and must also advertise and make the public aware of the virtues of its product.

Maybe the wheat industry has been a little too reluctant to blow its own horn. As Dr. Hegsted pointed out in his talk, "You have been told so often that you had a poor nutritional product, that you believed it. Furthermore, you did not work very hard or efficiently to disprove it although evidence to the contrary has been around for a long time."

And so I want to say to the wheat industry: Don't sell yourself short--you have a wonderful product--one that the world needs--a product which is easy to transport, will keep almost indefinitely, and can be prepared into an amazing variety of delicious and healthful foods. Wheat is a golden grain that contains within itself almost all the elements essential for human life.

Discussion: The problem of milling facilities in some of the developing areas was discussed. Milling wheat into flour is minor in countries such as India and leavened breads are little used. However, about 90 percent of the cereals used are ground in crude village mills to a wheat meal of about 95 percent extraction. There are adequate facilities for this traditional product.

The program of P.L. 480 export of wheat was discussed in terms of its effects on other wheat exporting countries and the possibility of further expansion. Because most of the wheat goes to countries with severe food shortage, who are already using available exchange currencies for food purchases, it is not probable that the concessional sales reduce international markets. Probably there is room for further expansion but there are limitations in facilities for receiving, storing, and distributing wheat in many areas.

THE WHEAT SITUATION AND OUTLOOK

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The wheat situation and outlook are highlighted by an expected reduction in carryover stocks on July 1, 1963, which would be the second consecutive reduction in the carryover, and by the likelihood that the new wheat legislation may keep the carryover July 1, 1964, from increasing. I will cover, among other items, the situation in the current year, the program and outlook for 1963, and the program for 1964 and subsequent years.

The wheat situation for 1962-63, with related historical information. The total wheat supply for the marketing year which began July 1, 1962, is about 10 percent below both the record supply in 1960-61 and the supply in 1961-62. The decrease is due to a reduction in the carryover and production. The 1962 wheat crop is 11 percent below last year's crop but only 3 percent below average. An increase of about 75 percent in the spring wheat crop over last year's drought-reduced crop was much more than offset by a decrease of about 25 percent in the winter crop from the good crop of last year, since winter wheat constitutes the larger portion of our crop.

Even though the estimated 1962-63 supply is below last year's, it still represents two years' domestic use and exports. Table 1 shows the items which make up the 1962-63 estimated supply compared with earlier years. Distribution items are also shown.

Domestic disappearance for 1962-63 is estimated at slightly over 600 million bushels, about the same as the average disappearance in 1957-61. Exports in 1962-63 are assumed at 600 million bushels. While still very large, they are substantially below the levels of the 2 previous years because of the near-record world wheat crop in 1962. With a total supply of 2,405 million bushels (Table 1), a carryover of about 1,200 million bushels would be left on July 1, 1963. A carryover of this size would be about 100 million bushels below that on July 1 this year and would be the second consecutive reduction. Stocks were reduced by about the same number of bushels during the past marketing year.

Acreage allotments and marketing quotas have been in effect for wheat each year since 1954. Since 1954, seeded acreage has held at about a 55-million-acre minimum allotment level, except in 1957 and in 1962. The Acreage Reserve of the Soil Bank Program reduced acreage to 49.8 million in 1957 and the Wheat Stabilization Program resulted in a seeded acreage of 49.1 million acres in 1962.

Table 1. Wheat: Supply and distribution, United States, 1956-62

	Year beginning July						
	1956	1957	1958	1959	1960	1961 1/	1962 2/
	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.
Supply							
Carryover on July 1	1,033.5	908.8	881.4	1,295.1	1,313.5	1,411.2	1,304
Production	1,005.4	955.7	1,457.4	1,121.1	1,357.3	1,234.7	1,095
Imports 3/	7.8	10.9	7.8	7.4	8.2	5.9	6
Total	2,046.7	1,875.4	2,346.6	2,423.6	2,679.0	2,651.8	2,405
Domestic disappearance							
Food 4/	482.3	485.9	496.8	496.2	496.0	499.6	502
Seed	58.0	63.0	64.3	62.9	64.0	56.6	63
Industry	.5	.3	.1	.1	.1	---	---
Feed 5/	47.6	41.9	47.0	40.7	45.8	73.0	40
Total	588.4	591.1	608.2	599.9	605.9	629.2	605
Exports 6/	549.5	402.9	443.3	510.2	661.9	718.3	600
Total disappearance	1,137.9	994.0	1,051.5	1,110.1	1,267.8	1,347.5	1,205
Stocks on June 30	908.8	881.4	1,295.1	1,313.5	1,411.2	1,304.3	1,200

1/ Preliminary. Distribution items for 1961 are partly estimated.
2/ Projected.
3/ Imports include full-duty wheat, wheat imported for feed, and dutiable flour and other wheat products in terms of wheat. They exclude wheat imported for milling in bond and export as flour, also flour free for export.
4/ Includes shipments to United States Territories and wheat for military food use at home and abroad.
5/ This is the residual figure, after all other disappearance has been taken into account; feed for 1961 appears to be larger than it should be.
6/ Exports are of wheat, including flour exports for relief or charity by individuals and private agencies. Shipments are included in domestic disappearance for food.

Yields per acre rose sharply from 1954, reaching an all-time high in 1958. Yields have continued at high levels and resulted in large crops. Yield per seeded acre in 1962 for all wheat is the third largest of record, though 3.7 bushels below the record in 1958 and 2.4 bushels below the second largest

of record in 1960. Yield per seeded acre of spring wheat this year is a record at 26.4 bushels per acre but the average for all wheat was lowered by a 15 percent reduction in the yield of winter wheat. Winter wheat was attacked by a serious infestation of stem rust, spreading northward from Nebraska into South Dakota, Wyoming and Minnesota. Also, yields were lower in Texas and the eastern States.

Because our prices are high relative to competitive world prices as a result of the price-support programs, all U. S. wheat exports require export subsidy payments. In the case of wheat grain, export payments are paid in grain; for flour, export payments are in cash. Exports under the various export programs are financed by the Government in addition to the subsidy payments. These programs, which include sales for foreign currencies, barter and various donation programs, have materially increased the volume of our exports.

Exports of wheat in 1961-62 totaled 718 million bushels, 9 percent larger than the previous record in 1960-61. Exports of wheat as grain totaled 608 million bushels--the largest quantity ever exported by the United States or by any other country in a marketing year. Flour exports in 1961-62 totaled 109 million bushels, grain equivalent, up 10 percent from the year before but 44 percent below the record. The record for U. S. flour exports was reached in 1946-47, when 195 million bushels were exported.

The expected decrease in U. S. exports in 1962-63 from a year earlier are in line with an expected substantial decrease in world wheat trade from the record level achieved in 1961-62. Competition is expected to be strong among exporting countries for existing markets. World import requirements may be some 150 million bushels less than the estimated 1,702 million bushels shipped in 1961-62. The principal basis for the expected decline is the higher wheat production reported by countries in Western Europe, North Africa, and parts of Asia.

Import markets in Western Europe are expected to have much smaller requirements in 1962-63, probably 100 million bushels less than last season. A record wheat crop seems likely to reduce import requirements to the quality hard wheats and durum needed to supplement indigenous wheat production.

Record or near-record crops in India and Pakistan should cause some reduction in import requirements. Mainland China is expected to continue as a large importer, though probably importing less than during the past 2 years.

Larger exportable supplies are available outside the United States this season. Canada's surplus will be moderately larger. France has about 135 million bushels for export. Australia will have a larger 1962 wheat crop and a larger surplus if current prospects materialize. After several years of below-average crops, Syria may return to an export position this season as is the case of Algeria, Tunisia, Morocco (former French North Africa), where last year's crop was very small. Argentina seems to be the only foreign exporter with poorer prospects than last year.

The Secretary of your Program Committee asked me to cover some specific points that would be of interest to you. One of these was the overall size of

Table 2. Wheat: Estimated supply and distribution by classes, United States, 1960-62

Item	Hard red winter	Soft red winter	Hard red spring	Durum	White	Total
	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.	Mil. bu.
1960-61						
Carryover, July 1, 1960	1,002	10	218	18	66	1,314
Production	794	190	188	34	151	1,357
Imports 1/	---	---	8	---	---	8
Supply	1,796	200	414	52	217	2,679
Exports, including shipments 2/	434	54	32	6	138	664
Domestic disappearance 3/	258	134	145	26	41	604
Carryover, June 30, 1961	1,104	12	237	20	38	1,411
1961-62 4/						
Carryover, July 1, 1961	1,104	12	237	20	38	1,411
Production	755	203	116	19	142	1,235
Imports 1/	---	---	6	---	---	6
Supply	1,859	215	359	39	180	2,652
Exports, including shipments 2/	487	56	42	16	119	720
Domestic disappearance 3/	305	135	130	18	40	628
Carryover, June 30, 1962	1,067	24	187	5	21	1,304
1962-63 4/ 5/						
Carryover, July 1, 1962	1,067	24	187	5	21	1,304
Production	547	155	183	67	143	1,095
Imports 1/	---	---	6	---	---	6
Supply	1,614	179	376	72	164	2,405
Exports, including shipments 2/	424	35	40	3	100	602
Domestic disappearance 3/	263	133	140	27	40	603
Carryover, June 30, 1963	927	11	196	42	24	1,200

1/ Excludes imports for milling-in-bond and export as flour. 2/ Includes shipments to Alaska and Hawaii and the U. S. Territories. Includes exports for relief or charity by individuals and private agencies. 3/ Wheat for food (including military food use at home and abroad), feed, seed and industry. 4/ Preliminary. 5/ Imports and distribution are projected.

Note: Figures by classes in this table are not based on survey or enumeration data and are therefore only approximations. Class production is established on the basis of the quinquennial wheat-variety surveys. CCC inventories are reported by classes and total stocks have been broken down by classes largely on the basis of CCC holdings of each class. Exports and shipments, by classes, are estimated on the basis of "inspection for export" for wheat as grain and on the basis of the area from which exports are made for flour. Data for 1929-57 are in The Wheat Situation, June 1962, pages 22-23.

stocks in principal exporting countries. They reached an all-time high on July 1, 1961, of 2.3 billion bushels, over 3-1/2 times the size they were only 9 years earlier. Very large world exports in 1961-62 reduced July 1, 1962, stocks by about 400 million bushels to bring stocks down to about 3 times the stocks in 1952. The distribution of July 1, 1962, stocks in the 4 countries was as follows: The United States had 68 percent of the total; Canada, 23 percent; Australia, 5 percent; and Argentina, 4 percent.

Another item of interest that was suggested is the volume of dollar exports. In the last 7 years, U. S. exports for cash averaged 161 million bushels, which was 31 percent of total exports with the various Government programs accounting for 69 percent. In our projections, we have been using about 160 million bushels to represent dollar exports. To this we added about 30 million bushels to represent exports for relief or charity by individuals and private agencies, which we assume would be about average over the years, and we arrive at a total of 190 million bushels. Putting it another way, if we would discontinue financially aiding exports, continuing only the per-bushel subsidy, our exports in the foreseeable future would probably be in the neighborhood of 190 million bushels. This would be only 28 percent of the high level attained in the past 2 years. Publications containing data on exports for dollars, as well as under Government programs, by country of destination, for the 7 years ended with 1960-61, are available on request.

Analysis of the July 1, 1962, carryover by classes. Of the net reduction in the carryover of all wheat at the end of the 1962-63 marketing year, stocks of hard red winter wheat, which are in greatest surplus, may be down about 140 million bushels, while stocks of soft red winter may be down about 13 million (Table 2). Little change may occur in the size of the carryover of white wheat, hard red spring may be up slightly, but stocks of durum may be increased sharply, by possibly 37 million bushels. Production of durum in 1962 was increased greatly as a result of the special provisions of the program for 1962 which allowed increased acreage for this class of wheat and because of good growing conditions.

The decline in carryover stocks of hard red winter is the first since 1958. But at 1,067 million bushels on July 1, 1962, they are still 75 percent above the 611 million bushels of 1958. Stocks of hard red winter wheat continue to account for the major portion of the total carryover and are large because our production is so very large. Hard red winter wheat accounts for about 50 percent of our total wheat production, about 40 percent of all wheat consumed as food in the United States, and about 55 percent of all the wheat we export.

The carryover stocks of the various classes on July 1, 1962, as a percentage of the 1957-61 average disappearance (domestic use and exports) are as follows: Hard red winter, 177 percent; hard red spring, 103 percent; durum, 17 percent; soft red winter, 14 percent; and white, 13 percent.

While the general level of wheat prices is related to the support level, the price of each class also reflects its own supply and demand situation. The price of soft red winter at St. Louis, reflecting local mill and export demand, usually averages about the same or above the price of hard red winter at Kansas City. However, over much of Illinois the unusual export demand for

hard red winter wheat has strengthened hard wheat prices for export movement by barge, raising prices of the hard wheat above that of the soft red wheat.

The price of No. 1 Dark Northern Spring wheat at Minneapolis in the past 5 years averaged 17 cents above the price of No. 2 Hard Red Winter at Kansas City. In recent years, the price of white wheat at Portland has been high relative to other markets as a result of the strong export movement.

Early season wheat prices this year resisted the usual sharp harvest-time drop. This was the result of the small 1962 crop, the increased level of price support, the use of sedimentation values to establish price support premiums on hard wheat, and the continued good demand. Prices did decline gradually since the beginning of the new crop year, but in October they recovered and prices of hard wheats rose to near the levels reported in July. In mid-October, prices of most wheats, with the exception of soft red winter, were near the effective support price. With a reduced export movement, prices of soft red winter have been below the effective support. Exports of white wheat have been down, resulting in a continued gradual price decline. However, prices of this class are still at about the effective support level.

The wheat program for the 1963 crop. The seeding of winter wheat this fall was largely guided by the program on which farmers voted favorably last August. Since that time, the Agricultural Act of 1962 has become effective. This Act does not require farmers to change their plans and they continue to be eligible for price support at $1.82 per bushel (minimum national average support), if they do not exceed their farm acreage allotment based upon the 55-million-acre allotment.

The Act does provide, however, a voluntary diversion program for the 1963 crop of wheat similar to the voluntary feature for the 1962 crop. To participate in this program, producers must divert to conservation use at least 20 percent of (1) their wheat acreage allotment, or (2), in the case of small farms with allotments of less than 15 acres, their allotment or their average 1959, 1960, and 1961 seedings of wheat, whichever is larger. Producers who make the required diversion will be eligible for diversion payments equal to 50 percent of the value of normal production on the diverted acreage, based on the support rate, and for payment at a rate of 18 cents per bushel on the normal production of the acreage devoted to wheat. The 1959 and 1960 average yield is used in deriving normal production. The maximum acreage diversion on any farm would be either 50 percent of the allotment or, in the case of small farms, up to 10 acres.

Any grower who signs to divert acreage in 1963 must reduce his acreage by the amount of the signup or he will lose price support eligibility, as well as all payments under the voluntary portion of the program.

The price support payment of 18 cents per bushel will be made in payment-in-kind certificates and CCC will assist farmers in marketing the certificates. CCC will be permitted to sell wheat from its stocks at not less than the $1.82-price-support level to cover the cost of those certificates that it redeems for farmers.

The diversion payment may be made in either cash or certificates. This same provision was included in the 1962 Wheat Stabilization Program and all payments were made in cash.

The signup period for the special voluntary 1963 wheat program runs from October 15 to December 14 for winter wheat. The signup period for spring wheat will be after the first of the year.

The wheat outlook for 1963-64. The 1963 diversion program differs from the voluntary diversion portion of the 1962 program in several ways. One of the most important differences is the provision requiring compliance with 1963 signup intentions as a condition of price support eligibility. In 1962, farmers were required to reduce their acreage allotment by 10 percent while as much as an additional 30 percent could be diverted on a voluntary basis and price support eligibility was not affected by a change in farmers' plans to divert acreage on the voluntary portion.

Because of the differences in the 1962 and 1963 diversion programs and the timing element (the 1963 diversion program came into effect after much of the winter wheat crop was seeded), it is difficult to draw a comparison between the voluntary participation in the 1962 program and expected voluntary participation in the 1963 program. However, assuming that the voluntary diversion in 1963 is about 7 million acres, the harvested acreage might be about 47 million. This would be 3 million acres more than was harvested in 1962. With a continuation of the upward trend in yields, a yield of 26 bushels per harvested acre might be obtained. This would be slightly more than 1 bushel above that in 1962.

The resulting 1963 crop of 1,225 million bushels may be about equal with expected domestic disappearance and exports. As a result, the carryover on July 1, 1964 might show little change from the 1,200 million bushels currently estimated for the end of 1962-63. Without the voluntary diversion program, stocks would increase.

The wheat program for 1964 and subsequent crops. There are two principal features in the permanent wheat provisions of the Food and Agricultural Act of 1962. The first eliminates the 55-million-acre minimum national allotment and authorizes the Secretary to estimate the total requirements for wheat in the coming year. He then announces a marketing quota and a commensurate acreage allotment large enough to meet those requirements after allowing for some reduction in stocks. However, the marketing quota cannot be less than 1 billion bushels. Diversion payments are authorized for 1964 and 1965 on an acreage equal to the difference between their new allotment under the Act and their allotment based on the 55-million-acre program. Producers can also voluntarily divert additional land.

The second principal feature of the new wheat program is a change in the price support system. A marketing certificate program is substituted for the present price support system. The certificates provide a means of distinguishing between wheat for food and some portion of exports to be supported at between 65 and 90 percent of parity and wheat for feed and seed which would be supported at a level consistent with the support level for feed grains and world wheat prices.

The marketing certificate program provides greater flexibility for farmers to produce wheat for feed, if they want to, provided that an acreage diversion program for feed grains is in effect. The certificate program also will enable the Government to reduce its stocks by reducing the allotment sufficiently to bring production below projected requirements. Farm income from wheat could be maintained with the certificate system even though production is reduced. If more than one-third of the producers voting in the referendum reject the program, price support would be provided at 50 percent of parity to cooperators.

Another important provision in the permanent wheat program is that the exemption under which any farmer could grow 15 acres of wheat would be terminated permanently. These small producers could either come into the program or stay out, but they would have to meet certain requirements regardless of their choice.

The Act provides also that the Secretary may increase the allotment for any type of wheat which would otherwise be in short supply. This will make it possible to gear the supply of different kinds of wheat to the market demand. If an acreage diversion program is in effect for feed grains, the Secretary shall permit producers to substitute wheat for feed grain on feed grain acres, or vice versa, to such extent as not to impair the effectiveness of either the wheat or feed grain programs.

Adequate authority is provided in the Act for the Secretary to administer the Wheat Marketing Certificate Program in a manner agreeable to both wheat producers and the wheat and flour industry. Authority is provided also for the Secretary to make an orderly transition from the 1963 wheat program to the 1964 program in a manner which will avoid both windfall profits and unexpected losses which might otherwise occur.

Discussion: Mr. Post was queried as to the source of the estimate of 7,000,000 acres of wheat land to be diverted next year. The estimate was based on judgment of several experts based on a comparison with last year's program. Mr. Post thought it would have been higher if the winter wheat had not already been planted. None of the winter crop that looks good is likely to be diverted.

THE ROLE OF THE EXPORTER IN WHEAT MARKETING

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Of all the groups that are represented at this conference, an exporter represents that group which finally acts to implement the movement of wheat for export, and we are gratified that our activities are receiving attention, scrutiny, and, we hope, constructive criticism.

It would be possible to discuss our role from a number of angles, but I will endeavor today to concentrate on one of the critical factors in sales of U. S. wheat, and that critical factor is price. Based on the record exports of the past crop year, a casual observer could easily and rightfully say that any nation that exported as much wheat as we did must certainly have had a competitive price, which, on the average, is true. I will comment on this matter again later on.

As has been said on many previous occasions, the subsidized or net export price of hard winter wheat, our surplus quality, has varied rather little over the past dozen years. Every status quo has its beginning, and this status quo began with the first International Wheat Agreement. Since that date, inexorable changes have taken place in the world about us, but the diplomats and negotiators have arrived at the same annual answer as to the right world price for wheat. Hindsight now tells us that the export price has been too high to clear away available supplies, and too high to enable potential buyers to act through commercial channels.

It is helpful to understand that the practical procedure in pricing world wheat under the I.W.A. has been to establish the range for Canadian Manitoba wheats, as a standard of value, and other wheats are then priced at discounts, or in isolated cases, at premiums over Manitobas. For example, for several years U. S. prices of our basic Grade 2 hard winter were established at a discount of \$2.00 to \$3.00 per metric ton below 3 Northern Manitoba C&F Europe. In the past year, the price discount has widened to \$5.00 to \$6.00 per ton. Until a year or so ago, the above formula worked out so that prices of hard winters were higher than Manitobas in Japan, and, as is well known, we were not selling in that market. The widening of the European discount and special pricing situations for Japan are helping somewhat in reaching that market.

U. S. export interests have spoken about the inequity of our quality differentials or price discount for a number of years. We feel that the reductions which have been made, relative to Manitobas, have substantiated our judgment, but not as yet in a positive way because we have not become sufficiently competitive to make satisfactory inroads into the dollar markets. To understand this, it is necessary to realize that the price discount for 2 hard winter for export is considerably less than the spread between our own milling spring wheats and ordinary hard winters in domestic markets. A close look at prices on a recent date reveals that 1 hard winter was selling in Kansas City

at about $2.19 to $2.20 per bushel, and 1 dark northern spring, 14 protein, was selling at $2.50 per bushel in Minneapolis. The latter grade compares favorably to 3 Northern Manitoba, so it is apparent that our milling industry is paying $11.00 per ton premium for the 14 protein spring wheat over hard wheat. We are trying to compete abroad with hard winters at a discount of $5.00 to $6.00 per ton under 3 Northern Manitoba. This comparison sheds light on why it is difficult to sell in dollar markets, and conversely, it illustrates why our better qualities are not being exported. At present subsidy levels, our better qualities are priced above Manitoba wheats.

Currently 3 Northern Manitoba, 14 protein, 65 to 70 sedimentation, is offered in Europe at about $74.50 per metric ton. A comparable 14 protein 1 dark hard winter is offered at $73.00 to $73.50 per ton, or about a dollar discount. The sedimentation value of such offerings will range from 40 to 45. There is, of course, some 14 protein hard winter that carries a higher sedimentation value, but this is eagerly sought by U. S. millers, and would be priced over the 3 Northern Manitoba. These prices give some idea as to our competitive situation.

With reference to sedimentation, exporters are frequently asked about its effect on our activities. I believe it is correct to say that exporters generally took the sedimentation announcement in stride. We were and are prepared to make sales on sedimentation guarantees. Very few sales are being made with sedimentation guarantees. This matter has received much discussion in this country. We understand that U. S. millers generally do not use it to finally measure the quality of a particular lot of wheat, but prefer a complete milling and baking test. Perhaps sedimentation does not describe all aspects of wheat, just as proteins or grades do not describe them. Mr. Zeleny has said that the test was developed as a quick practical means of reflecting the difference in gluten strength between strong and weak varieties of wheat.

Therefore, the sedimentation test can be used in a general rather than a specific way. For example, I quoted the values of 3 Northern Manitoba, 14 protein, and 1 dark hard winter, 14 protein. The vast difference in sedimentation values of the two qualities confirm generally the markets' judgment of their relative values, but may not tell a miller specifically what he needs to know about either grade. To proceed further, sedimentation values of exports of 2 yellow hard winter tend to average about 25, 2 hard winter 30 to 35, etc. As is well known, our higher grade spring wheats have sedimentation values comparable with Manitobas, which is as expected.

To summarize, the sedimentation test can be a useful tool for the negotiators in establishing price differentials, which are the clues to our participation in dollar markets. It will be useful to describe the quality of our crop in a general way. However the test's use in selling actual cargoes of wheat will generally depend on its adoption by millers. So far, there is little evidence that they will accede to this particular change.

Another factor the exporter should discuss is grade changes. A number of groups feel that changes will increase our share of the market. We frequently see that our grading system is compared to Canada's and is found wanting. Any wheat that grades 1 Northern Manitoba meets certain specifications except

protein and will be very similar from year to year, if growers produce wheat of that quality. Because of climatic conditions, Canadian protein contents tend to be more uniform, even though no guarantees are given. Our spring wheats could be similarly graded. But because of our range of protein, it is more important to segregate spring wheats than in Canada. Our hard winters cover a much wider range in baking quality. One hard winter wheat can be produced in Texas, Kansas, Illinois, and Montana, but the quality from each state may vary considerably. Our marketing system quickly measures differences and that is why we have price variations on qualities shipped from different areas. Undoubtedly, the question that is being asked about grades is whether or not grades can describe wheat as our markets do. We are attempting to do this through sedimentation tests. It goes without saying that it is a challenging assignment.

Undoubtedly, continuing studies will tend toward further refinements in our grading procedures. We encourage any improvements. The meaningful developments will be those that measure baking performance. It is performance that determines the value of wheat, and our markets measure such performance. We know that recleaning of wheat has had much discussion; nevertheless it is realized that cleaned wheat does not measure baking performance. Our grades can be improved to give incentives for deliveries of cleaner wheat from the farm to ultimate destination.

To summarize, we applaud efforts to improve our standard; however, we need to realize that technological changes will not overcome social and political problems that plague us. As in many areas of human endeavor, technical changes come much faster than social changes. Administered price changes involve social changes and come very slowly. Administered or government prices tend to be tied to an obsolete historical base.

When exporters speak of the inflexibility of wheat prices, we refer to the administered price established by the diplomats and negotiators. As explained earlier, our hard winter export prices are controlled by such actions. Our red winter prices have a reasonable degree of freedom. The subsidy today is based on hard winters but is applicable to red winters. When our farmers produce more red winters than we need for domestic use, the domestic price tends to decline to a point so that it moves into export channels. In some years, red winters are programmed under Public Law 480. This facilitates its removal and may inhibit either the domestic price decline or entry under loan. Nevertheless, there has not been a carryover of consequence for a number of years. If P.L. 480 buyers were free to exercise the same choice as dollar buyers, that is, to buy those grades and classes which in their judgment offer the best value, it appears that larger amounts of red winters would be taken. This is the reason that freedom of choice is not freely given.

To further illustrate that prices do change in the market place, we need only recall that hard amber durum wheat sold for export last year at \$3.50 to \$3.60 f.o.b. Duluth. This demand was from dollar buyers, for gold, so to speak, and was so urgent that in the U. S. we used much less durum than is normal, using substitutes and reducing shelf inventories of products to accommodate the dollar demands.

Again, conditions have changed. The larger durum crops in the world have reduced the price, and carryovers will be increased again. We doubt that last year's short crop was in Canadian or U. S. plans, and it illustrates one of the problems of supply management. We have experienced similar difficulties occasionally with white corn, in which case imports were necessary to augment our short supply.

At the outset, I mentioned that a casual observer would have rightfully concluded that in order to export over 700 million bushels in one year, we must have had a competitive price. About 70 percent of our wheat exports are made under P.L. 480. Sales under Title I with payment in foreign currencies constitute the most important part of such transactions. Such sales are called concessional sales, which means that something has been conceded.

It may be that the history of the beginning P.L. 480 has been written but I haven't seen it. We can probably assume that the idea was incubated in some committee meeting and someone either said "We have to sell some wheat" or asked the question "How can we sell some wheat?" It's only by asking the right question that you can get the right answer, and the answer was that we could sell a lot of wheat by taking payment in restricted foreign currencies.

It will serve no purpose to try and estimate the price concession that has been made since 1954. But I believe we can accept that it has been fairly substantial, and we have stimulated a demand for wheat that now seems much larger than was anticipated. A 1957 forecast that the United States would export over 700 million wheat in 1961-62 would certainly have been shrugged off as loose thinking. There is elasticity to the demand for wheat on a worldwide level, and lower prices triggered the demand. The trading activities that have accomplished this business have been carried on within the formal pricing structure of the International Wheat Agreement. The buyer pays the same net export price as dollar customers, except in foreign currency at an agreed exchange rate.

The point is that we have today two prices for wheat. One is for dollars, and in fact, for gold. Therefore, any dollar sale helps to relieve our balance of payments problem. The other price is for foreign currencies and hence is lower and is made to the new developing countries. It is to this area that we have sharply increased our sales, whereas other major exporting countries have had the greatest success in dollar markets. These sales have in some cases been based on long-term credits. By cutting just slightly under our prices, the Soviet Union or any other country has an uninhibited entry into the dollar market. These countries effectively clear out their exportable surplus in dollar markets, either for cash or credit. France, in order to foster French wheat sales for export, has been granting a supplementary subsidy, over the automatic Common Market subsidy, or as they call it, restitution, for third countries. This subsidy was cancelled last week because tonnage c special destinations had reached the desired quota. This additio of France has interfered with exports of our red winters.

The situation in feed grains and soybeans is, for example, different. In the past 3 or 4 years we have sharply increased do these commodities, at small or no subsidy. The subsidy on feed g

gradually declined and barring undue acreage restrictions we can compete in both hemispheres and contribute to the export volume that is so vital to the U. S. We have had no subsidy on soybeans for export. The production of soybeans has been encouraged in some degree by a sophisticated measure--namely, to subsidize export of the surplus oil which results from the crush required to provide needed meal supplies, so that burdensome stocks of soybeans have not been collected.

In short, the U. S. has retained the freedom to price dollar sales of feed grains and soybeans. We have developed growing markets all over the world and are making good use of our comparative advantage in world trade. Our producers should not only be interested in retaining this advantage, but should assert the advantage to the utmost.

There are many reasons for the dilemma in which we find ourselves in wheat and just as many reasons will tend to prolong the dilemma of pricing wheat, but it will not help to ignore this problem. In mathematics, use of the term <u>problem</u> implies that there is a solution, but in this case we may have to use the term <u>situation</u> instead of <u>problem</u>.

We have a policy of supporting domestic wheat prices above world price levels. We are not doing this on feed grains and soybeans, but even so, doing it on wheat is not an exception to many of our economic policies. Scores of items sell at higher prices in the U. S. than they do abroad, including labor, sugar, automobiles, ocean freights, and many others. We can ship wheat in a foreign flag vessel from the Gulf to Europe for 10 to 12 cents a bushel; this figure doesn't buy transportation in a U. S. flag vessel. As long as we choose to support domestic wheat prices and various other factors over the world market a subsidy is necessary. We must accept this fact. This subsidy needs to be sufficient to compete to a larger extent in dollar markets, as well as to the needy areas which we are now supplying at much higher subsidies. It is realized in many quarters that high support prices in the U. S. complicate our negotiations to reduce export prices and to eliminate import duties.

At last year's meeting of the I.W.A. countries, it appeared that much time was spent on discussing an increase in the maximum prices under the pact. U. S. exporters were not represented, but we just assume it took a great deal of time to increase the price by 12-1/2 cents. In theory, higher net prices would reduce our subsidy, assuming domestic levels remained unchanged, and assuming demand remained constant. During the course of the past year and prior to the increase in maximum prices, our net prices were advanced 6 to 8 cents but somewhat less than Canadian prices, as has been previously explained. The latter country was in position to demand higher prices, because of the shortage of protein wheats in the U. S. and because of the extraordinary demand from China. As we increased our net prices, it meant that we also increased our sales price to P.L. 480 countries, and as a consequence received larger amounts of foreign currencies.

So far, no significant move has been made to increase dollar prices this year, since the increased maximum price became effective. Without doubt, those who negotiate with the Common Market countries would like to find a means to demand higher prices so as to counteract the high import duties they place on

wheat. It is conceivable that major exporting countries would try to get together on such a counteroffensive, which would soon help to break down tariff barriers. We of course assume that traditional importing areas would reduce import duties rather than pay higher prices, provided they effectively faced such an alternative. It may well be however that lower wheat prices will eventually break the barriers, as the politician who reduces the cost of food is generally favored. The Common Market area includes some countries who export and some who import, so internal conflicts on their common agricultural policy will continue, but in the long run, consumers will have a voice in the policy.

At the May meeting of the World Food Forum, Dr. Willard W. Cochrane spoke about the world food budget and looked ahead into the years 1980 to 2000. I would like to quote briefly from his talk as he comments on the changing form of trade. He said, "I project net food imports from the developed countries to increase markedly to $10 billion in 1980 and $30 billion in 2000. At present net food imports are near $1 billion, due almost entirely to U. S. foreign aid." Dr. Cochrane continues: "Practical politics in both exporting and importing countries will probably require that part of this very great increase in food movement take the form of commercial trade (although perhaps under some form of long-term credit or concessional terms)."

Dr. Cochrane is referring to all foods, and he speaks about a distant future. In essence, he is suggesting that eventually our dual price system for export wheat will be more closely aligned than it is today, and our thoughts should be channeled in that direction. It is obvious that there are many difficulties involved. The International Wheat Agreement restricts our actions to some extent. It was designed perhaps to stabilize prices, but as we see from our disposal activities, prices have not been stable and ways were found to move around it.

Undoubtedly next year's speaker on this program will be free to speak, if he wishes, about this unsolved problem. But it needs to be talked about if we are really interested in establishing a sounder export program for U. S. wheat producers, who control much land that is ideally suited for wheat production and are just as able to compete abroad as are corn and soybean farmers.

The new developing areas continue to move towards shortages of food that must be made up by import. The major quantities of food and feed that move in world trade are produced in highly industrialized countries. The demand is there and the opportunity is available to us, through the use of latest technological methods, to accommodate this demand. When Henry Ford started producing the Model T car, he insisted on establishing a price at which it could be sold in volume, and technology enabled him to reduce his costs.

With reference to P.L. 480, some features of that program are designed or tailored to approach a dollar sales status. Title IV provides for sales against dollars on long-term credits. It's use has been limited but it can be helpful to developing countries. Sales for long-term dollar credits have been used by other exporting countries. Further concessions may be needed to activate this program, but such buyers can eventually become cash dollar buyers without a convulsive change. Already, several countries have graduated from P.L. 480 to dollars, such as Japan and Spain, and it will be helpful to provide another intermediate step.

Another section that has developed some business for the U. S. is the barter program. Barter is earlier in history than buying and selling and is in some ways, more intricate. The barter program was discredited in the middle 1950's because it had been unduly extended and had replaced our own dollar trade. Other exporting countries recognize it as a competitive tool and elect to criticize it. Because, in history, barter has preceded ordinary buying and selling, and is today an intermediate step from Title I sales to dollar sales, it deserves greater attention and planning.

The Senate Committee on Agricultural Appropriations in a release on August 22, 1962, indicate their belief that there may be "greater benefit to the American economy to conduct a carefully planned program of trading surplus agricultural commodities for stockpile materials under this authority than in carrying on an expanded disposal program under Title I agreements." This points out that Dr. Cochrane's forecast of political considerations interests us in planning to facilitate greater dollar trade in wheat. To do that, we must come to grips with realistic pricing. President Kennedy has recently approved moves in this direction.

Before leaving the discussion of price, one further comment is in order. The export trade has asked the Department of Agriculture to publish subsidies that will enable us to make deferred sales. A quick look at today's futures quotations reveals that higher subsidies are needed for January and forward positions because of carrying charges. Suggestions have been made as to how this might be done. We are hopeful that some program can be worked out.

Another matter that I would like to touch on briefly is a method of selling grain under P.L. 480. Present regulations require that exporters make P.L. 480 sales f.o.b. vessel and importers are required to charter freight and arrange for loading at U. S. ports. The Great Plains group joined the exporters in a statement to the Department of Agriculture earlier this year and recommended that the Department amend its rules and regulations so that exporters could make sales C&F destination ports.

The reasons are very simple. The great bulk of the dollar trade in agricultural products is made C&F destination ports. The dollar buyers are free to buy as they please. It pleases them to buy C&F because it is cheaper.

One of the matters that complicates the sale of C&F grain under P.L. 480 is that 50 percent of the shipments must move in U. S. flag vessels and the Department of Agriculture pays a premium or subsidy for the shipment in a U. S. flag vessel as compared with a foreign flag vessel. At the outset of P.L. 480, this differential - as it is called - was negotiated by the exporter with the Department of Agriculture. Now it is negotiated between the foreign importer under P.L. 480 and the Department of Agriculture. The problem for the Department of Agriculture is the same except that they are dealing with foreign importers instead of U. S. exporters.

We believe that we can do the most efficient job if we charter the freight, arrange the accumulation and the loading of the grain. Foreign importers would not be concerned with delays at U. S. ports because this coordination would be fully the responsibility of the exporter.

The present system of requiring importers to buy f.o.b. vessel is cumbersome, uneconomic, and unnecessary. We fully recognize that the Department of Agriculture is required to regulate the amount of differential paid to U. S. flag owners. We can't subscribe to the belief that foreign importers are easier to regulate than U. S. exporters. We believe this regulation can be worked out to fully satisfy the interests of U. S. taxpayers and to provide U. S. taxpayers with the economies that result from C&F selling.

Although the Great Plains group joined with the exporters in this proposal, I'm not certain that their support of our position has been wholehearted or sufficiently active to be helpful. It is rather easy to understand the reluctance to take a strong stand on this issue because it is complicated, not easily understood, and it has been resisted by the Department of Agriculture. We hope, however, this will not deter them from continuing to think about this matter and to use their influence in accomplishing this change. This all ties in with the ultimate objective of merging commercial trade with present surplus disposal programs. Some of the original recipients of aid are now important dollar buyers. As Dr. Cochrane predicts, practical politics will lead to further developments of this nature in years ahead. It is not too early to tailor trade under P.L. 480 in the complete form of commercial trade.

Exporters of grain have been one of the United States' most effective foreign policy tools. History has shown us time and time again that a buyer-seller relationship based on sound two-way trade, is a constructive force difficult to match in foreign relations. International trade channels must be kept clear. Private industry working together with the government can do much to accomplish this objective.

<u>Discussion</u>: In discussing U. S. exports of wheat in relationship to Canada's, it was pointed out that historical patterns favor the latter. As an exporter the U. S. has had its hands tied by a foreign policy protective of others. Until our exporters became aware of this situation, there were serious disadvantages but now they have learned to live with them. Exporters' responsibilities for cleaning wheat were also discussed. The speaker commented that in any responsible business enterprise, goods desired by customers must be of the quality demanded or the business will fail. Clean wheat must be paid for, and it is frequently less costly to clean it at the receiving end than at the export point.

THE BULGUR STORY

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One phase of the bulgur story started in the Near East, possibly before Christ. In this country, bulgur has been produced on a small scale for at least 60 years. But the real bulgur story began when this fine wheat product became big time through the program to produce hundreds of millions of pounds for export to needy people of the world.

To the wheat growers of the United States, this program means several important things: (1) It offers an outlet for some of the 1.2 billion bushels of wheat in surplus stocks. (2) It offers an opportunity to prove to millions of people in the world that bulgur is an excellent food product worthy to become a supplement to rice in many areas and a welcome addition to the limited food supplies in other areas. (3) This program offers a solid basis on which to develop a taste appeal and demand for bulgur, which could ultimately result in substantial dollar markets in the developing countries. (4) As is already happening, it is spurring interest in our own country and thus helping to create a new market for wheat which has not heretofore been a significant factor in domestic wheat utilization.

Description of bulgur. Perhaps some of you are wondering at this point why we are so interested in bulgur and in what it is. Bulgur is a cooked wheat that is first soaked in water and then cooked in either steam or water, under pressure or at atmospheric pressure. Bulgur may be completely dried or it may be canned, containing perhaps 50 percent moisture. Removal of part of the bran is customary, and the bulgur may be cracked (or broken) or left whole. For export markets, dry bulgur is used, whereas for the domestic market, either dry or canned bulgur is suitable.

Compared with ordinary wheat, bulgur is much easier and quicker to cook and prepare for use. In the underdeveloped nations, bulgur is an ideal food because it requires a minimum of fuel to prepare and because it can be used in dishes to which the natives are already accustomed.

Compared with rice, bulgur offers the advantage of being more nutritious in both protein and vitamins. It is notable that outbreaks of beriberi (caused by vitamin B-1 deficiency) and kwashiorkor (caused by protein deficiency) have never been associated with populations whose diets are high in wheat products. Bulgur can be stored for long periods without loss of nutrients or deterioration of eating quality. Bulgur has an extremely hard vitreous surface very resistant to attack from insects and microflora. Furthermore, bulgur is virtually sterilized during cooking.

Background of export interest in bulgur. During the first half of this century, bulgur production in the United States was limited to two small companies in California and one in Massachusetts. Their production was mainly for local consumption but some was shipped to other parts of the country for sale

to people of Middle Eastern ancestry. Some was sold to overseas markets. This picture began to change dramatically during the 50's.

In connection with the wheat food research program at the Western Regional Research Laboratory, members of the Oregon Wheat Commission have met annually with our research group to review work in progress and to discuss mutual problems. One such visit occurred in the fall of 1950. Following the meeting, the Oregon group asked for suggestions of good restaurants in San Francisco. It was suggested that they try one of the famous Armenian restaurants which for years has served wheat pilaf (a seasoned bulgur) in various dishes.

Apparently the group liked what they ate, because after the meeting in the following year, 1951, they wanted to visit one of the bulgur plants in Fresno. Arrangements were made and the group saw how bulgur is made. Their report stressed that bulgur is an excellent food from both the palatability and the nutritional standpoint and justified further investigation.

In the ensuing two years, an investigation with the product was carried out at the Women's Christian College, Madras, India, under a joint project with the College, Millers National Federation, and Oregon Wheat Commission. The purpose was to determine the nutritional aspects, palatability, and keeping qualities of bulgur in a humid rice-eating country such as Southern India.

Locally trained food demonstrators visited villages in Madras and showed housewives how to prepare wheat, using the fuel and cooking facilities as they existed. It was demonstrated that with a minimum of instruction and education, an encouraging degree of acceptance could be developed.

The Oregon Wheat Commission felt that if enough demand could be created for bulgur, some organization would begin manufacturing it in the Pacific Northwest. The Commission developed interest through the use of bulgur in banquets and dinners and promoted it wherever possible.

In addition to the Millers National Federation, who cooperated in the Madras project, Fisher Flouring Mills of Seattle had become interested, and early in 1954 volunteered to undertake commercial production as part of a cooperative program to export wheat. Fisher had been studying bulgur production for some time to lay the basis for a pilot plant operation and had furnished bulgur to some meetings of the Oregon Commission.

By mid-1954 plans were developed for a cooperative undertaking among Millers National Federation, Fisher Flouring Mills, and the Foreign Agricultural Service of the Department to obtain 500,000 bushels of surplus wheat for processing into bulgur and to use the product to determine consumer acceptance by rice-eating Asiatics. The Fisher company, in consultation with the Western Regional Research Laboratory, set about to develop modern processing methods, and in 1955 a plant was placed into operation capable of producing 100,000 pounds of bulgur daily. By the time contracts were signed and production neared, domestic interest and demand had become great enough for Fisher to undertake retail distribution in the United States. Sales have increased and their products are distributed nationally.

Other interest in bulgur became evident in August of 1954. Senator Hubert Humphrey delivered to Congress a report entitled "New Outlets for Wheat." In it, he cited the investigation by Dr. Francis Joseph Weiss, Library of Congress, into food habits of Biblical times. He went on to show bulgur to be an excellent food suitable for export to needy people in rice-eating countries. Senator Humphrey made a strong plea for a comprehensive research project to determine the nutritive value and keeping qualities of bulgur and the possibilities through modern processing methods of preparing bulgur dishes for rice-eating areas.

Program for exporting bulgur. The contract with Fisher, written in 1955, provided that the bulgur was to be sold, not donated. Under this contract, Fisher exported some 25 million pounds of white wheat bulgur to 15 countries prior to July 1, 1961. This was an effort to determine the acceptability of the product and its commercial potential. Although this was not a highly successful venture, it did lay the necessary ground work for the program that was to follow.

Since 1957, certain charitable organizations have been distributing American surplus foods to areas of need throughout the world and have been endeavoring to obtain bulgur for this purpose. Through the efforts of many organizations and various individuals, approval under Title III of Public Law 480 was finally granted. When this new "Food for Peace" was begun, 60 million pounds of bulgur was contracted for an initial trial the first year. This program was undertaken with the stipulation that there would be no expansion unless bulgur was well received.

As a result of the favorable response from recipients of bulgur, the program was expanded to 300 million pounds for the current fiscal year. Apparently the amount of bulgur that could be made available is limited mainly by the ability of the welfare agencies to handle and distribute bulgur in the recipient countries.

The total of foreign food donations under Section 416 is estimated at about 3.6 billion pounds of food in the current fiscal year. You might be interested in a breakdown of this total--see Table 1. While bulgur is only fifth on this list, we must remember this is the first year of the expanded program to export bulgur.

Table 1. Foreign Program -- Section 416

	Fiscal 1963 -- estimated requirements	
Flour - wheat	1,400	million pounds
Nonfat-dry milk	740	" "
Cornmeal	470	" "
Vegetable oils	300	" "
Bulgur	250	" "
Pea beans	190	" "
Corn	90	" "
Wheat	80	" "
Cheese	30	" "
Butter, butter oil, oleo	24	" "
Rolled wheat	9	" "
	3,583	

In fiscal 1962, 2.7 billion pounds of food were distributed in 109 countries and territories to 68 million people, including 32 million school children. Total value was 1/4 billion dollars. Operation of this food donation program works out about as follows: The welfare agencies approved for participation (of which there are some 25) determine how much of each food item is needed and can be distributed in each country. The requirements for each foreign station of an agency are combined in the main office in the U. S. The agency then submits its request to AID (Agency for International Development) functioning as a part of the State Department. AID reviews these and prepares the total program, which is next submitted to the Interagency Staff Committee for approval (Departments of Commerce, Agriculture, State, Defense, etc.). The approved requests are returned to the welfare agencies who then place their orders with the Food Distribution Division of AMS. The orders specify recipient country, quantities of products requested, and rate of shipment.

After reviewing orders and seeing that they are in accord with the approval by the Interagency Staff Committee, Food Distribution forwards the orders to ASCS (Agricultural Stabilization and Conservation Service), who places contracts with the suppliers and pays for processing. The welfare agencies accept delivery of products at point of embarcation. They arrange for shipment and may actually pay shipping charges, although they are usually reimbursed later by ASCS. All distribution in foreign lands is handled by the welfare agencies. In the first four months of the expanded program on bulgur, 5 processors were given orders for 105 million pounds for shipment to more than 40 countries. Three-fifths of the total went to the Far East and one-fourth to Latin America. See Table 2.

Table 2. Major recipients of bulgur

Far East	64,000,000	pounds	61%
Latin America	28,000,000	"	27
Africa	10,500,000	"	10
Europe	1,400,000	"	1
Near East	1,100,000	"	1
Total	105,000,000	"	100%

The four major countries receiving bulgur (in millions of pounds) are shown below: Taiwan, 31; India, 11; Colombia, 8.6; and Brazil, 7.3. Thus we now have a program using 6 million bushels of wheat annually, and this amount can be expanded as conditions warrant.

Foreign acceptance of bulgur. Toward the end of the first year of trial use of bulgur overseas, the Food Distribution Division of USDA prepared a questionnaire designed to obtain information about how bulgur was distributed by the welfare agencies, how it was prepared, problems in its use, and acceptance of bulgur by recipients.

Much bulgur was utilized in institutions and in schools, and some was distributed to family groups. Recipes and instructions were usually given with the bulgur, or the bulgur was prepared in institutional kitchens by people trained in its use. The amounts distributed averaged perhaps 2 to 5 pounds a

month per person. Daily servings were common, and in some cases bulgur was served twice a day.

Probably the most usual way bulgur was served was mixed with beans, rice, barley, millet, or vegetables in soups, stews, etc. Some recipients used bulgur boiled, and also in pancakes and puddings. In another way, bulgur was prepared as a congee or gruel with rice or milk powder. One group reported use of bulgur with lettuce in a salad; and another, that breads and cookies were made with bulgur that had been toasted and ground. Typical comments about the reception of bulgur follow:

Chile. No problems in acceptance. Some institutions report that bulgur takes too long to cook even though soaked overnight.

Israel. Reactions were mixed, but in general there were no problems, except in the beginning, as the bulgur used generally in this country is of lighter color.

Korea. No problems were encountered since bulgur cooks and tastes about the same as barley, and barley is a common food in Korea. Bulgur is preferred over cornmeal and flour. It was accepted very well. An hour's instruction was given to all concerned, and they said it was an ideal food, gave them more strength for working in the fields than just rice.

Hong Kong. Taste-wise, Chinese consider it a poor substitute for rice. Most of the recipients accept it, as they have learned the value of this form of nourishment and the method of preparation.

Vietnam. No distribution problems, hearty acceptance. This product has no French or Vietnamese name, but is now referred to as the "American Rice."

Taiwan. General acceptance has been excellent, since bulgur cooks and looks like rice. Wheat products have good acceptability here.

India. Acceptance far better than we had hoped. The commodity has been warmly welcome and well consumed.

Most reluctance to bulgur was with adults. Several reports were received indicating much promise in teaching children to like and become accustomed to bulgur.

Korea. At first they act a little strangely to it and wonder what it is and prepare and eat it with much caution. But we find they learn really to like it, especially the younger folks.

Jamaica. Never before has the introduction of a new type of food been so willingly accepted and proved to be so popular in such a short time with the children. The children enjoy eating the food, especially when it is served as a cereal or with peas. The latter, they say, is richer than the Jamaican dish "Rice and Peas."

Bolivia. The following report of feeding children with bulgur came from the Bolivia Mission, Catholic Relief Services. It was prepared in soups, stews, and tortillas. At all places bulgur was well received and requests were made for more. As a result, the Mission is considering using bulgur in place of flour in the projected rural school lunch program. The Director of the Mission stated that "The Rural Schools function through Central Schools in towns of about 5,000 people called Nucleos. These Nucleos have many small schools dependent on them. For example the pueblo of Viacha, about 40 kilometers from LaPas, has two nucleos--one at Comiri, 15 kilometers from Viacha, and the other at Irpa Chico, 18 kilometers in another direction from Viacha. Together, these Nucleos have 65 rural schools with a population of 3,858 children depending on them. The schools range in size from 22 to 430. The smaller the school, the more remote it is, with some being 2 days by mule (the only possible way of getting in) from the Nucleo. In these places, it would be practical to replace the bread, which we plan baking and serving in the form of rolls, with bulgur wheat which has the equivalent nutritive value and which can be transported dry and prepared at the school in the same manner as milk powder, thus overcoming the difficulty of supplying fresh bread to these outposts."

While in this particular illustration there may be no net gain in wheat utilization, the story highlights the fact that bulgur is more adaptable than flour to many situations and hence is likely to be used where flour may not be used.

Prospects for dollar exports of bulgur. A long-term goal of this food donation program is to build up dollar export markets for our food products. At present most recipient countries do not have dollars to buy our wheat. But they are developing, incomes are growing, and sometime in the future they may have advanced economically to the point where they can go shopping with dollars. If these people have developed a taste for our food products, as appears possible in the examples cited, we can expect some of their money will be spent for bulgur.

Dr. Sherman E. Johnson, Deputy Administrator for Foreign Economics, ERS, USDA, said in the conference on the "Role of Wheat in World's Food Supply": "If food and fiber can effectively contribute to economic development that will result in building self-sustaining economies in the presently underdeveloped nations, total trade will increase. Eventually this is likely to result in larger commercial markets for our farm products. We have already seen this transition taking place in Japan and Italy. It is under way in Spain.

"Preliminary findings from a study being conducted in the Economic Research Service indicate that from 1950 to 1960 a 10 percent rise in per capita income in low-income countries was associated with a slightly more than a 10 percent rise in per capita imports of agricultural products from the United States. Countries with incomes of $100 to $200 per capita import only $1 to $2 worth of farm products per capita from the United States, whereas countries with per capita incomes of $800 to $1200 import $8 to $12 of farm products per capita."

Dr. Johnson said further that the period of transition to a self-sustaining economy is likely to take a long time in Far-Eastern countries. If self-sustaining economies are not established, those countries are not likely to stay in the Free World. So they are going to need our help.

We do not have to wait, of course, for these developing countries to become dollar markets. Industry is already hard at work. Several wheat groups and processors are attempting to develop commercial sale of bulgur throughout the world in countries able to buy our products. The October 23, 1962, issue of the Southwestern Miller has an article describing the efforts of Great Plains Wheat, Inc., to promote bulgur in Nigeria.

Domestic interest in bulgur. Bulgur is not a product just for export. Domestic sale of bulgur is increasing steadily, as well it should. Several factors have helped this growth. More companies are now producing bulgur for national distribution. Interest in the foreign program has created domestic interest. The growing knowledge of the relation between our health and the foods we eat has created new interest in wheat products such as bulgur. And research has contributed new products, new dishes, and new processes for bulgur. Steps are being taken to get bulgur into our domestic school lunch program.

The Western Regional Research Laboratory has taken an active interest in bulgur dating back to the early visits of the Oregon Wheat Commission. Studies have been made on processing methods and storage stabilities. A canned cooked bulgur product, called Redi-Wheat, both flavored and plain, was developed and market-tested in 1961 in a joint project by the Kansas Wheat Commission, Economic Research Service, USDA, and the WRRL. As a result of this test, Redi-Wheat is now available in many grocery stores throughout the Kansas area.

Another process for making bulgur was developed. This is a modernization and mechanization of the open-pot method used by nations of the Middle East. The system is designed to make large quantities of bulgur continuously at low cost in readily available equipment. The process involves presoaking wheat in increasingly hot water for 60 minutes, tempering the hot grain for 30 minutes, and cooking for 15 minutes in steam at atmospheric pressure. The entire soaking and cooking operation is carried out in simple, conveyor-type equipment. Total processing time is much less than with previously used methods.

The WRRL has "instantized" bulgur. Exposing bulgur to a hot (500°F.) air stream for 15 to 20 seconds expands each grain to about twice its original size. The expanded bulgur is crunchy and easily chewed and has a toasted flavor. Besides being good for eating dry, this bulgur reconstitutes quickly and completely when cooked in water.

Expanded bulgur is used in the bulgur wafer developed for civil defense stockpiling. The Defense Department has announced its intention of using this wafer in the stockpiling program as soon as commercial feasibility is demonstrated in the current trial procurement. An eventual procurement of one billion pounds of wafers is planned using about 17 million bushels of wheat.

Our Cereals Laboratory is developing new recipes giving bulgur the appeal necessary to attract domestic buyers who have already demonstrated their desire to buy new food products stressing convenience, variety, and glamour. The flavor of bulgur combines well with other flavors, yet it has the delicious and distinctive whole wheat flavor. The texture can be modified from the chewy character of whole-wheat kernels to the softer textures of cracked or broken kernels.

The new convenience products developed by WRRL from bulgur are in three main forms: canned, frozen, and expanded dry bulgur. Formulations and processing methods have been developed so far for about a dozen canned bulgur products and seven frozen bulgur specialties. These include barbequed and Boston baked bulgur, chicken fricassee and curry, cheese, beef, and lamb dishes, and several desserts. A line of frozen gourmet bulgur dinners deserves consideration by any manufacturer who plans to produce bulgur products.

Eight dehydrated instant bulgur mixes have been formulated using expanded or puffed bulgur. These include bulgur bavarian desserts and dehydrated vegetable and fruit salad mixes. These all have a gelatin base. The only heat treatment needed is the addition of one pint of boiling water to the contents of each package. In addition to the dessert and salad mixes, three dehydrated soup mixes are ready. In addition to these fully prepared convenience foods, recipes have been developed for making many bulgur dishes from either dry or canned bulgur. Copies of these recipes can be obtained from WRRL.

These recipes include dishes for every course of the dinner. Meats, poultry, and sea foods, or the liquids made from meats and poultry, are combined with bulgur to make very fine soups and stews. Vegetables, mushrooms, seasonings, and butter complete the recipes.

Bulgur is well adapted to recipes for entree dishes. It can be mixed with ground meats to make meat balls or meat loaves, patties, and stuffings, or can be mixed with seasonings, vegetables, and nuts for stuffing poultry, fish, and meats. Boston baked bulgur or barbeque bulgur, two of the convenience canned products mentioned, can be combined with wieners for a tasty dish.

Interesting side dishes are made with bulgur combined with cheese, butter, canned cream soups, vegetables, mushrooms, and seasonings. Excellent salads combine bulgur with cucumbers, greens, cabbage, carrots, onions, peppers, parsley, pineapple, oil, seasonings, mayonnaise, pickles, and eggs. To complete the dinner, bulgur desserts are attractive, delicious, and nutritious. Indian puddings, chocolate, pineapple, and butterscotch bavarians, and fruit delights are some of the desserts made with bulgur.

Discussion: The following table was presented to indicate the five companies who have participated in the current government bulgur procurement in the first four months of this fiscal year:

Fisher Flouring Mills Co., Seattle, Wash.	(lbs.)	41,500,000
River Brand Rice Mills, Houston, Texas		32,000,000
Columbia Malting Co., Chicago, Ill.		25,000,000
Pillsbury Company, Minneapolis, Minn.		4,500,000
Froedert Grain & Malting Co., Milwaukee, Wis.		2,500,000
Total		105,500,000

Cost of processing was indicated to be $1.50 to $1.75 per 100 pounds. It was stated that the five producers listed use a method for processing developed by Fisher Flouring Mills, or a modification of the method. Sales of Redi-Wheat (a canned wheat product produced for market trial sales in Kansas) were reported to be holding steady without publicity and that sales rise when local promotion is used. In addition to Fisher Flouring Mills, three other producers sell bulgur in domestic markets.

WHAT MILLERS AND BAKERS ARE DOING TO STIMULATE DOMESTIC CONSUMPTION

Dudley E. McFadden
American Bakers Association, 20 North Wacker Drive, Chicago, Illinois

The main object of our Association is to build a greater demand for wheat flour products, in all those forms which reach the consumer through the efforts and the art of the commercial baker. It is my intent to show you what methods we use to reach this objective and to present some figures which, I think, will indicate that we have had a certain measure of success.

Perhaps it is well briefly to delineate the three organizations which function so efficiently in our work. There is always a certain amount of confusion as to the relationship and the operations of the three groups known as the American Bakers Association, the American Institute of Baking, and the Bakers of America Program.

The ABA is a trade association whose membership consists primarily of the wholesale bakers--the brand-name bakers whose products are found in retail groceries, in restaurants, institutions and so on. The multiple-unit-retail operator and the home-service baker to us are wholesalers and are included in our membership.

The ABA performs all the normal functions of any trade association: arranging industry meetings, keeping members posted by bulletins on matters of national and local interest, setting up committees for things of specific industry interest, maintaining a Washington office and so on.

Membership in the American Bakers Association is confined 100 percent to bakers. The American Institute of Baking is the educational and research center for the baking industry. It has its own building, apart from the ABA. It conducts an advanced-course baking school, a sales seminar, short courses in baking for allied tradesmen, product and nutrition research, a nationwide sanitation service, and operates the most complete reference library on baking in existence.

When a baker joins the ABA he automatically becomes a member of AIB. We collect the dues at ABA, allocate about half to AIB, but in addition allied trades organizations can and do belong to AIB--flour mills, yeast companies, paper suppliers, machinery manufacturers and so on. Seventy bakers are elected to the board of governors of ABA. AIB has a board of directors of 17, of whom 9 are also on the ABA board, the other 8 being allied trades personnel.

Now the third name is the Bakers of America Program, which is my department. This is actually a part of ABA but financed separately, wholly apart from the dues to ABA. In my office, we are responsible for general promotional activity for the industry. Of the funds collected each year, from voluntary subscriptions by bakers, about 80 percent is allocated to the American Institute of Baking to finance the consumer service department of AIB. If you are slightly

confused, you have company. So are a lot of bakers who for quite a number of years have financed the ABA, the AIB and the Bakers of America Program.

The promotion which centers in my office through the Program is primarily one of nutrition education. The Program got under way back in 1947, and as is usual, it started with national advertising. We ran full color ads in all the big national magazines. By 1952, television was beginning to dominate the advertising scene and costs were becoming prohibitive. We shifted first to network radio, but, in the spring of 1953 killed all the consumer advertising, created our consumer service department as now constituted, and broadened our general promotional campaign. Big as the baking industry is, we simply could not raise enough cash to buy television nationally.

So we turned to other ways of reaching the consumer, to correct false ideas about bakery foods, particularly enriched bread, and to build a knowledge of the high nutrition in these foods, again particularly enriched bread. Enrichment came early in 1941, but by 1953 it was apparent that the consumer still did not know of enrichment, what it is, the tremendous benefits which resulted. Even professional people in the fields of medicine, dietetics, home economics, and nutrition were not thoroughly familiar with enrichment--did not know that a very large number of top nutritional authorities rated enriched bread as high nutritionally as whole wheat bread.

And if any of you are under the impression that you can convince Mrs. Homemaker that she should eat dark breads in quantity, there is an opening in my office for you at a fancy figure. No matter how hard you try, consumers who have a free choice in every outlet, in every market still select white breads about eight or nine to one to whole wheat, partial wheat, or other dark breads.

This should not irritate the wheat grower. It takes 100 pounds of wheat to make 100 pounds of whole wheat flour and it takes 140 pounds plus of wheat to make 100 pounds of white flour. About 90 percent of our material is based on the complete diet--the basic four. The greatest part of our campaign is to promote bread as a vitally important part of every meal, every diet, but we do not promote bread alone in this nutrition education campaign. The result has been a truly tremendous acceptance of our materials and an enthusiastic acclaim for the personnel who are responsible for the direct contact work with educators.

We have a scientific advisory committee of some stature and an educational advisory committee of equal stature in its field. We have lost two important members of our scientific committee in the past year or so--Dr. Norman Jolliffe, who headed the bureau of nutrition of New York City, and Dr. Conrad Elvehjem, president of the University of Wisconsin. On the committee at present are Dr. Longenecker, president of Tulane; Dr. Borsook of Cal Tech; Dr. Sebrell of Columbia University and several others of comparable qualifications. The educational committee has on it Dr. Hein of the American Medical Association, Hazel Stiebeling of the USDA, Helen Starr of Minneapolis, Phil Lewis of the Chicago Board of Education, Justine Smey of the Long Island schools, to mention a few. Each of our publications in nutrition and educational fields is submitted to these people for discussion and suggestions before it is printed and distributed.

Now to move into the type of materials we are using. (Anyone who wishes copies should write to me at 20 North Wacker Drive, Chicago 6.) Here is a booklet which seeks to set the record straight on bread, as a basic food product. It asks and answers the common questions which many consumers raise. It debunks false ideas, gives industry data. Something over a million copies have been distributed to consumers, either by our membership or through our own staff contacts. Here is another publication, which traces the history of bread from 6,000 B.C. to present day. More than 1.5 million have been distributed, mostly through educators to grade and high school students. Another popular item with grade school teachers is this puzzle. It also has crossed the million mark in distribution. Note it tells the nutrition story of bread, each segment giving a nutritional element in bread, what it is, and how it serves in helping hold health. This booklet, produced by the Consumer Service Department of the AIB, is for grade school levels. It tells how bread is made in a modern bakery; gives bread's nutrition story. It is in constant demand from teachers; is purchased in large quantities by our members, for distribution to schools or to hand out as students tour the bakery. A revised edition will be available soon, to include the new continuous mix system of bread making.

This is our most popular booklet, "Eat and Grow Slim." Somewhere near 10 million of these have been printed. The booklet bears a statement of approval by the Council on Foods and Nutrition of the American Medical Association, is recommended to doctors by the AMA. It surprises me to note how many doctors write us, attach a check to purchase 100 or more copies of this publication. Of course, the greatest distribution is by our offices and by our members.

What recommends the booklet most is its sensible approach to weight reduction, its completely nutritious menus. They contain some of all the basic foods--milk and milk products, meats, fruits, vegetables, and of course bread. But pleasing to the dieter is that you'll also find desserts in the menus, yet they still hold to the level of 1,500 calories per day.

"Turn to Sandwiches" aims at helping a busy homemaker to prepare a nutritionally complete meal, using bread and fillers as the major factors. It also provides recipes for sandwiches to be used as carried lunches; gives party sandwich suggestions. At a nickel per copy, this is the best, most usable sandwich booklet produced. These are not fancy sandwiches, but the type which appeal to every busy homemaker. Obviously, the booklet sells not only bread, but meat, cheese, peanut butter and a wide variety of other foods. It is distributed mainly by our membership, direct to women's clubs and to consumers by offering in advertising. It also has been offered by food editors of publications and on radio and television. It gets a strong pull whenever and however offered.

Here is a stuffing guide, using bread with fowl or in meats and fish, also very popular with homemakers. Toast is finding increasing usage, according to reports from equipment people, and this book gives a variety of ways to use toast, with other foods, not just for breakfast but at luncheon, at suppertime, for snacks and so on.

Undoubtedly, you will all recall the strenuous nutrition education program which was conducted during World War II. At that time USDA promulgated a

group of seven basic food groups which would provide a complete diet. A few years ago, this was reduced to a Basic Four. This item was created to illustrate the four food groups, from which daily selections of food should be made. Naturally the cereal food group, including bread, is given prominent position, but our good friends in the other food industries are quite happy with this chart, they tell me.

Each press run is a million copies on the Foodway, and the only problem is filling orders from teachers, home economists, nutritionists, dieticians, nurses--even the Red Cross. The back page spells out nutrients, tells in which food they appear. We distribute it as a wall chart and in a notebook size. It is accompanied by a so-called check chart, which youngsters use to indicate their dietary habits. It helps in leading them into better habits. At their impressionable ages, the Foodway, when used properly by teachers, can do much to stimulate right eating.

This is a mobile, sent in one piece to the teacher, and the youngsters assemble a balanced diet. If the foods are out of balance, the mobile does not hang straight. Bread is prominent, but everything goes so well with bread, it makes a nice item on which to hang the other foods.

Here is a new publication issued last year, designed mostly for use in science classes of junior high schools. It uses the scientific approach to the good diet. As I recall, when word of it reached the science teachers the Consumer Service Department was almost inundated with requests. The same was true with this item, the second in the series. This is for high school and again uses the scientific approach to diet, good eating, good health. It is proving highly acceptable in every area.

The Consumer Service Department produces a variety of other items, some illustrated here, but I do not want to take time to discuss each. Let me merely emphasize that every piece of material has but one aim--to help build a better market for the products made by bakers. To do this, the approach used by the staff, as I said earlier, is to build bakery products as a vitally important part of the complete diet. In doing so, the staff builds heavily on the importance of the <u>complete</u> diet. That is why the material is so readily accepted by every educator. As a matter of fact, it would take the rest of today to read you the spontaneous letters of appreciation which have come to the Institute from educators and professional people in the fields of health and nutrition over the years of our educational program.

Audio-visual materials take a good part of our budget each year. Our first motion picture was "Your Daily Bread," which tells bread's nutrition story and shows how bread is made in a modern wholesale bakery. Dr. W. W. Bauer, at the time we made the movie, was director of the Department of Health Education of the American Medical Association. He appeared in the movie and paid high tribute to bakers for the enrichment program. We have made 700 prints of this film, placing nearly 300 in school audio-visual centers. Bakers have bought more than 200 prints for local use. The balance we circulate on loan to schools, clubs and others. Demand is very heavy from September through May.

Our second motion picture was designed to help educate junior high students into the benefits of physical education and the vital role that good eating plays in good mental and physical health. It was prepared with the advice and counsel of a special committee of the National Education Association. Six hundred prints have been made, with more than 250 in audio-visual centers and the rest circulated from our office. It is very popular with teachers.

We produced a 40-frame filmstrip also telling bread's nutrition story and how bread is made, for use in grade schools. We have placed more than 25,000 prints in grade schools. They are used repeatedly year after year in several grades in each school. Last October we released to schools a set of two strips--one for kindergarten and first grade; the other for second and third grades. Nearly 20,000 sets have been sent to grade schools and the flow of comment from teachers is highly complimentary.

In all these audio-visual items, we promote bread, but we include strong emphasis on the fact that the good, healthful diet must include some of all the basic foods. There is no charge for the filmstrips nor for the copies of motion pictures sent to school systems for repeat circulation through their audio-visual centers.

We have had for some years several spot promotions--the first on breakfasts, the second on outdoor eating, and the third on desserts. Our members obtain these breakfast posters, hang them in supermarkets or restaurants, build their advertising on the theme--at least some of them do--of starting the day right with a good breakfast. We do a national publicity job at the same time, and encourage schools to stage breakfast demonstrations. One large State Farm Bureau jumped on the idea when they saw our posters and held a state-wide contest, awarding prizes to students preparing good breakfast posters. We have co-operation from other sources interested in the breakfast market.

We set up July as national picnic month in 1952. These posters are used by our members in supermarkets to stimulate interest. And we have had a tremendous support from hundreds of other organizations interested in outdoor eating--food suppliers and processors, equipment people, department stores, sportswear people, soft drink and beer producers, even oil companies, camera companies, automobile people and many, many others.

We think it has helped build the outdoor eating market. We are told by the people who make the casings that wiener sales totaled five billion in 1952, crossed 12 billion in 1961. Reports from charcoal makers, paper plate suppliers, and others show astounding increases in sales of their items in the ten year period.

When we set up July as national picnic month, our good friends at the Wheat Flour Institute established August as national sandwich month. Just to give you an idea of the tremendous publicity which has resulted from this campaign, here are a few clippings--a few out of literally thousands which appear every year. The combined and co-ordinated effort of our two groups has done much to build sales of bread, rolls, and other wheat flour products through the summer.

Our dessert promotion in the fall is based on traditional items--donuts, pumpkin pie, mince pie, fruit cake. It is pretty much a publicity campaign combined with the use of these posters by bakers and grocers.

If I had time, I would show you our very big and continuing campaign of food page publicity which is conducted by the consumer service staff. Quickly I will run through a few clippings which illustrate how bread figures prominently on the food pages of newspapers all over the country each year, in national magazines, over radio and television stations. These selections merely give you the type of material our test kitchen produces, photographs, and distributes, but it is impossible to show the actual results. Tens of thousands of clippings are received each year with these recipe items.

In addition, today the stature of bread in the diet is at the highest level in history. Note these columns by medical writers and others, including enriched bread in various diets. These columns reach millions of readers each issue and are of vast importance to anyone seeking to sell bread, flour, or wheat.

I have made no mention of the remarkable work of our staff of field nutritionists, but there has never been a more important work done for the baking industry, and, therefore, the wheat and wheat flour industries, than this particular segment of our operations. There are only eight of these women, who have covered 48 states for the past ten years. We paved the way to some extent with a $90,000 per year ad campaign in the medical publications. The Wheat Flour Institute took over this campaign a few years ago, to enable me to allocate that amount of money to heavier literature distribution.

These women work in contact with key people in every area, telling them our nutrition story, providing teachers with quantities of our material for use in instructing other people. Our women have been called upon hundreds of times to serve as nutrition lecturers before regional and state meetings of school lunch directors, dieticians, home economists, nurses--even meetings of doctors and dentists. What have they accomplished? Let me read for you a statement made just two weeks ago by the chairman of ABA at our annual convention. He is a baker, a hard headed businessman who has been in our industry for four decades. His opinion should be considered somewhat valuable. Here I quote: "I have no intention of going into great detail about the work of the Bakers of America Program. You have all been exposed to it for a goodly number of years. No doubt you are not as fully aware of what has been going on as you should be. We bakers don't take time to read as much of our mail as we should. But let me give you my very blunt opinion. Of all the functions of ABA, of all the functions of the AIB, there has never been a more important activity for the baking industry than the work done under the banner of the Bakers of America Program.

"No activity of ABA or of AIB has accomplished as much for us bakers as the Program, particularly through the efforts of the Consumer Service division. For the past nine years particularly, you bakers have had working for you right in your own territories the most dedicated bunch of people I ever hope to meet. The Chicago staffs of the public relations department at ABA and the Consumer Service department at AIB and the women who make up the field nutrition staff, have combined their efforts to building in every direction the knowledge of, the appreciation for, and the use of bakery foods.

"They have built the stature of a product which had been derided for years. They have elevated it to a place of prominence in the thinking, the planning and the recommendations of the leading authorities in medicine, nutrition, education and dietetics in this nation. They have created an atmosphere of respect and liking for your products, making possible to you an area in which it is much easier to work. Your brand name advertising for your bakery foods now is reaching consumers who are aware that the product which you make is contributing materially to the welfare, the health and the general well-being of every member of their families."

Ten years ago a vast percentage of the population looked upon bread as a starchy food which has little but calories to offer to the diet. It was the first thing removed from a reducing diet. I have no scientific studies which I can quote you, but there are many indications that today bread is recognized as a high-quality food, providing vitally important nutrition--protein, vitamins, and minerals--which in terms of percentage of contribution to the diet far outweigh the contribution in calories.

Far more people today know that bread should be included in the diet, not simply because it is a high-quality product which has a history dating back 8,000 years, but because, in terms of cost per serving, it contributes more of the things the body needs than does any other food.

Chances are this audience prefers some type of bread other than the popular, soft, bland white loaf. You have company--possibly as much as 10 percent of the population--but the other 90 percent make up the market which results in the baker using nearly 80 percent of all the flour consumed in the United States--flour which calls for about 400 million bushels of wheat. I'll ride with the majority.

A last slide to tell you whether we are making progress in our campaign. This is a weekly report compiled from some of our members. It equals over sixty-million pounds of bread. The base line is 1954. Note that in recent weeks we have held several percentage points above the year-ago level, but more significantly note that we are riding about 18 percent above 1954. I understand the population growth from 1954 to 1962 is about 15 percent. It appears we are recording not just a tonnage increase, but an actual increase in per capita consumption of bread.

The figures would be even better, we think, if this chart also included some of the grocery chain figures. But it does not. No chain stores are reporting bread sales to our office but we know very well their volume is up.

I conclude with the simple statement that our members are convinced that continued educational work, aided by the flour millers and the wheat growers who have banded together in many states, will continue to pay off, that such effort will bring a steadily increasing demand for wheat by the baker. We have proof in small test markets; we have proof in the chart I have just shown you; we have proof in the testimony of authorities that they are recommending more bread in the diet.

We invite your assistance in every way possible, for the benefit of the entire nation and especially the grower of wheat. Our belief is that in not too many years, the baker will need at least fifty percent more wheat than he now requires.

CEREAL PRODUCTS IN PAPERMAKING

F. R. Senti
Northern Regional Research Laboratory, USDA, Peoria, Illinois

One needs to empty only one day's accumulation in the wastebaskets at home or in any office to become aware of the tremendous amount of paper this country consumes. Most of our purchases, at a grocery, drug, or clothing store, are packaged in a paper box, carton, or bag. Corrugated paper boxes have largely replaced wooden boxes and crates for the shipment of articles ranging from fresh fruit and vegetables to refrigerators and stoves. Paper bags replace those formerly made of burlap or cotton for flour, cement, fertilizer, and the like. Despite the coming of television and radio, the publishing industry uses increasing quantities of paper each year for newspapers, magazines, and books. As Table 1 shows, domestic production of all types of paper and paper products in 1961 totaled 35,769,000 tons. Adding to this 5.725 million tons of paper, including 5.433 million tons of newsprint we import, less exports of 1.216 million tons, our consumption amounts to 40.278 million tons or about 400 pounds for each man, woman, and child. Production and consumption have shown a steady increase for the past 10 years, rising at a rate of about 3 percent per year, which is greater than our population increase. This rate is expected to continue and some predict that paper production will reach 56 million tons by 1975.

Uses of starch in paper. Cereal starches have a long history of successful use in the paper industry. This record, combined with the magnitude of the market and its pattern of steady growth, makes this industry a most attractive area in which to seek further applications of cereal products. Current cereal products, principally starch, comprise about 1.5 percent, on the average, of the weight of paper and paper products produced. Some papers such as newsprint use no starch; others, such as boxboard, may contain 3 to 4 percent starch by weight as an adhesive. Since each 1 percent of cereal product in paper represents about 20 million bushels of grain equivalent if added as starch, or about 10 million bushels if added as whole grain, the benefits to be gained from successful

Table 1. Pulp, paper, and board: U. S. Production 1961 (1000 short tons)

Paper, total		15,833	Paperboard, total		16,597
Newsprint	2074		Container board	9308	
Groundwood	944		Folding boxboard	2926	
Machine coated	1846		Special foodboard	1578	
Bookpaper	1977		Set-up boxboard	636	
Fine paper	1892		Special paperboard	2149	
Coarse paper	3982				
Special ind. paper	773		Construction paper and board, total		3,209
Sanitary paper	2099		Construction paper	1375	
Tissue paper	246		Insulation and hardboard	1834	
Total for all types	35,769				

new products are impressive. By chemical, biochemical, and physical treatments we endeavor to create new products from cereal grains that will do a better job in the making of paper than existing products now used, or that fill a need not now met by any existing product. In this endeavor, we must compete with the synthetic chemical industry, which has similar objectives and seeks to replace cereal starches in many of their present applications in paper.

Let us consider the functions a cereal product can serve in contributing to the properties of paper or as an aid in its manufacture. In paper making a dilute slurry of wood pulp is filtered through a moving screen, there depositing a uniform layer of matted wood fibers which, after drying and calendering, forms a smooth sheet of paper. Properties of the paper primarily depend on the type of wood pulp used but can be modified to advantage by additives either incorporated along with the pulp or applied to the paper after the sheet is formed. Indeed, sizes and coatings are mandatory if surface properties needed by certain papers are to be obtained. As another example, strength properties of paper can be increased by addition of 2 to 3 percent starch to the pulp slurry (so-called "wet-end addition"). This results in adsorption of starch on the wood pulp fibers, improves bonding of one fiber to another in the sheet, and increases dry strength of the sheet. There are limits, however, to the amount of starch that can be advantageously incorporated in this manner. One limitation results from the fact that only part of the starch added to the pulp slurry actually adheres to the pulp fibers, and starch retention decreases rapidly after the pulp has adsorbed 1 to 1-1/2 percent starch by weight. The unabsorbed starch drains away with the water when the sheet is formed and is lost. A second limitation is that paper becomes brittle if more than 5 to 6 percent unmodified starch is incorporated in the sheet. Later, I shall discuss some recently developed modified cereal starches and other cereal products that enhance properties of paper and have promise as wet-end additives in amounts approaching that of the wood pulp.

Surface sizes are applied to paper and paper products to improve printing qualities by laying the "fuzz" of protruding fibers and by filling pores, thereby presenting a smooth surface which has reduced ink absorption. Strength properties also are improved by sizing paper. Modified starches are commonly used as sizes and are applied not only to book, bond, and similar papers, but also to container board or corrugated boxboard that are printed or lithographed for display of advertising.

Another large outlet for cereal products, particularly starch, in the making of paper is as an adhesive. The "slick" papers used in magazines for the reproduction of photographs are coated with clay that is bonded to the sheet with a starch, protein, or synthetic resin adhesive. An even greater use for adhesives, one in which starch is used almost exclusively, is in the manufacture of corrugated boxboard where the adhesive serves to bond the corrugated interliner to the two exterior layers of liner board.

Dialdehyde starch. Now I should like to describe progress in our work aimed at developing applications for cereal flours and other cereal products in the paper industry. The first example is dialdehyde starch (DAS). This new product was developed at our Laboratory a few years ago, and after considerable applications research, by ourselves and industry, it is now on the verge of large-scale use as an adjunct in making paper and paper products.

Dialdehyde starch is produced by the chemical oxidation of starch with electrolytic regeneration of the oxidant used. Reactive aldehyde groups are introduced into the constituent sugar units of the starch. Even though all the sugar units are oxidized, starch retains its characteristic granular form (Fig. 1) and is still insoluble in cold water. As a result, there is much less

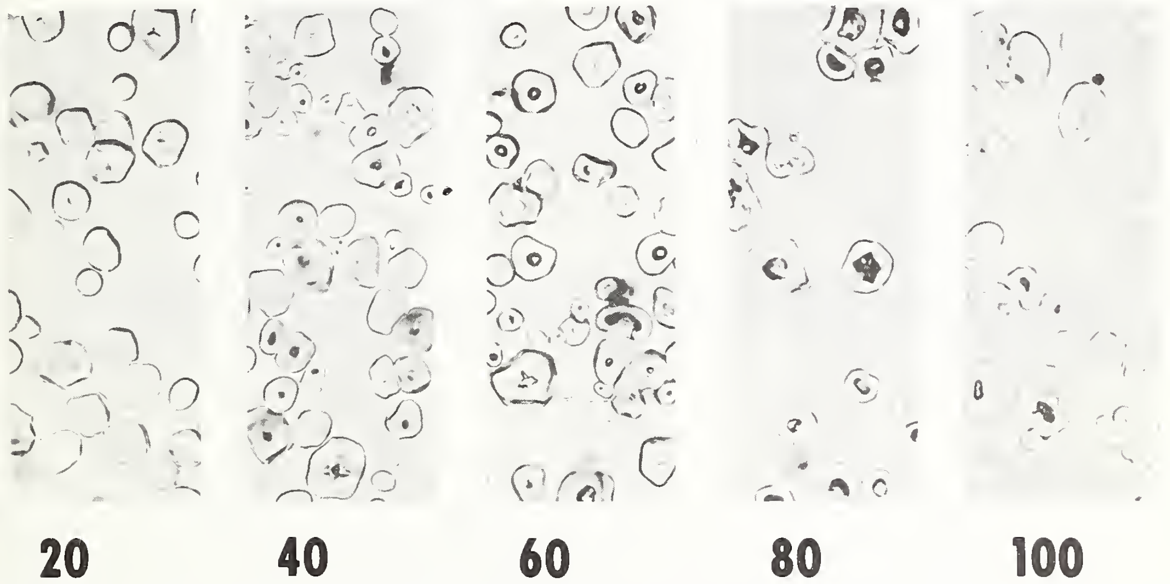

Figure 1. Microscopic appearance of periodate-oxidized starch (500X). The numbers represent percentages of oxidation.

solubilization of starch than when oxidized to a comparable extent by other reagents. Consequently, the product can be recovered by simple filtration or centrifugation, and losses in its manufacture from solubilization are minimal.

The aldehyde groups of dialdehyde starch react with certain of the chemical groups in cellulose, proteins, or in starch to form bonds that remain strong in the presence of water. This reaction is in marked contrast to that of starch products currently used in papermaking, which are quickly swollen and weakened when wet with water. Practical application of the reaction of dialdehyde starch with the cellulose of wood pulp fibers is in the production of

papers for which wet strength is a requirement. Examples are paper toweling, facial tissue, and bag paper. Wet strength has been obtained hitherto by incorporation of synthetic resins in the paper.

We first prepared papers of high wet strength by applying a solution of dialdehyde starch as a surface size to the finished paper. This method however cannot be used with such products as toweling and facial tissues, because wiping papers require that the wet-strength agent be incorporated in the pulp slurry. This requirement posed problems for dialdehyde starch, since it dissolves best in solutions that impart a negative electrical charge to the dialdehyde starch molecule. Since the dispersed pulp is also charged negatively, the dialdehyde starch and pulp fibers repelled each other. The result was that most of the dialdehyde starch stayed in the water and was not retained in the pulp when the sheet was formed on the Fourdrinier machine. Further research has resulted in three methods whereby high retention can be obtained.

The first method developed was to increase the concentration of alum, a chemical commonly used in papermaking, in the pulp slurry. This served to neutralize the electrical charge effect but posed other problems in the papermaking process and, hence, was limited in usefulness.

The second method was to incorporate starch containing positively charged groups into the pulp slurry before adding dialdehyde starch. Positively charged starch molecules are attracted and adhere to negatively charged pulp fibers; the pulp fibers then present a positively charged surface which attracts dialdehyde starch molecules with their negative electrical charge. Positively charged starches are commercially available as the so-called cationic starches. Table 2 shows how the wet strength of paper is improved by incorporation of as little

Table 2. Effect of added DAS on wet and dry tensile strength

Level of addition, %		DAS retention	Breaking length, km.	
Cationic starch	DAS	%	Wet	Dry
none	none	none	0.23	8.0
none	2.5	9	1.00	9.1
1.5	0.25	96	1.33	10.2
2.5	0.75	78	2.32	10.6

as 1/4 percent dialdehyde starch and 1-1/2 percent of a cationic or positively charged starch. Strength increase from this combination of starches is greater than that from 2.5 percent dialdehyde starch alone.

The third method, our most recent development, and the approach most promising for industrial use, has been to introduce a positively charged group into the dialdehyde starch molecule itself by appropriate chemical reaction. These new products, called cationic dialdehyde starches, require no other adjunct to increase their retention and give excellent strength increases at low levels of addition. Their efficiency is illustrated by the experimental results present in Table 3. We recently completed preparation of several lots on the 18-inch Fourdrinier at Forest Products Laboratory, Madison, Wis. Figure 2 is a photograph of the papers produced, which include bleached and unbleached toweling and bag paper.

Table 3. Cationic DAS machine trials

Product	Cationic DAS, % Added	Cationic DAS, % Retained	Tensile increase, % Dry	Tensile increase, % Wet	$\frac{\text{Wet tensile}}{\text{Dry tensile}} \times 100$	Absorbency,[c/] sec. Control	Absorbency,[c/] sec. Treated
Kraft bag	1.5	90	30	1260[a/]	31	40	41
Unbleached sulfate towel	0.5	90	25	920[b/]	30	14	12
Bleached sulfite towel	0.5	84	42	---	37	14	22

a/ 30 min. wet tensile test. b/ 30 sec. wet tensile test. c/ Drop test, 25 mg.

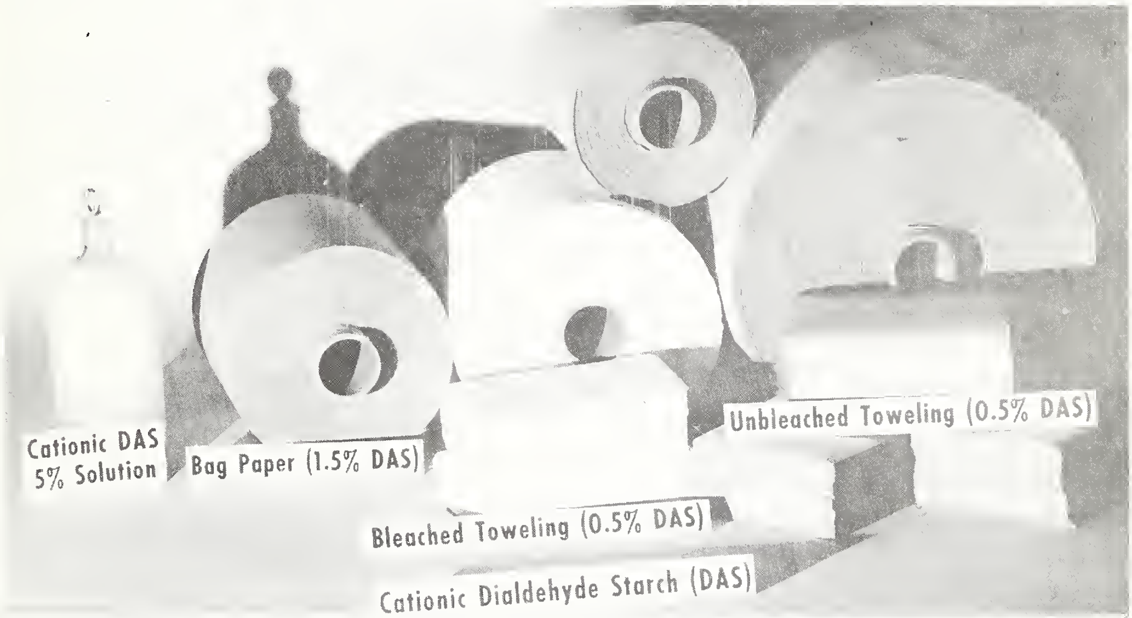

Figure 2. Experimental papers produced with cationic dialdehyde starch.

Dialdehyde starch has additional properties that favor its use as a wet-strength agent. A curing storage period is not required to develop wet strength, whereas an extensive cure is essential with many synthetic resins currently used. Paper therefore can be immediately shipped to the customer and no additional warehouse space is required. A further advantage is that wet strength is retained for the time needed by a paper towel, tissue, or grocery bag to serve its purpose; on prolonged soaking in water, the strength gradually decreases and the paper disintegrates. This has obvious advantage in the disposal of paper in a sewage system or in recovery of paper for repulping at the point of manufacture. Papers in which wet strength is achieved by incorporation of synthetic resins require special pulping methods for recovery of broken or imperfect sheets.

Dialdehyde starch has potential applications in other types of paper products. Table 4 shows how incorporation of 1-percent dialdehyde starch in insulating board gives marked increases in modulus of rupture and tensile strength, both measured wet and dry. (To get 1 percent DAS, we added 2.5 percent

(O.D. pulp basis) DAS, plus 2.5 percent (O.D. pulp basis) Cato (a commercial cationic starch), from which we get a retention of 1.0 percent DAS.)

Table 4. Insulating board strength, experimental vs. commercial

	Experimental board (25% newsprint)		Commercial
	Control	DAS treated	
Density, lb./cu. ft.	13.7	13.9	18.5-19.5
Modulus of rupture, p.s.i.			
Dry	250	410	250-400
Wet	20	110	65
Tensile strength, p.s.i.			
Dry	130	300	170-280
Wet	7	70	39

A practical advantage of the insolubilization of protein by reaction with dialdehyde starch is the improvement of wet-rub resistance of papers coated with the milk protein, casein. Table 5 compares a casein-dialdehyde starch coating (containing 0.125 part DAS and 12 parts casein) with a control coating made from casein alone. Samples of commercially coated papers also are included. The loss of coating weight in the Adams tester was least for the dialdehyde starch-casein coating, which also ranked "excellent" in the finger-rub test.

Table 5. Commercial vs. DAS-casein coatings

	Wet-rub resistance		
	Adams		Finger-rub
	540 g.-10 sec., mg./strip	1040 g.-90 sec., mg./strip	
Casein control	10.5	42.0	---
DAS-casein	0	1.3	Excellent
Commercial			
Letterpress	23.4	84.7	< Poor
Offset	2.7	57.7	Good
Label	1.1	2.4	Excellent

Chemically modified wheat flour for paper sizing and coating. Proteins have long been used as coating adhesives in the paper industry in competition with starch, even though their cost has been more than double that of starch. Superior properties of the proteins have justified added cost. This suggests that products might be developed from chemically modified wheat flour in which advantage is taken of possible superior properties contributed by the wheat proteins. Cost inherent in the separation of starch and protein as the separate components would be avoided and more economical products would be produced.

The properties of the principal wheat flour protein, gluten, must be altered drastically, however, if flour is to serve as a paper size or coating adhesive. Indeed, the cohesive properties of gluten, which give it the elasticity and insolubility that are responsible for dough formation and entrapment of gases in leavened breads, are a disadvantage in a size or coating. One reason lies in the method of machine application of a size to paper; this is illustrated in Figure 3. A solution of size is sprayed on both sides of the paper just before it passes between two rolls, which allow only a thin layer of

liquid to be deposited on the paper. Any undissolved material in the solution, such as gluten particles, tends to be rejected by the rolls and concentrates at the nip. Ultimately, the concentration of such particles reaches a point at which they are forced through the rolls, causing imperfections on the surface of the paper. This was the experience reported by paper companies who tried flour as a paper size during World War II. (Wheat Starch and Wheat Flour, Chapter XIX, Tappi Monograph Series No. 3, pp. 102-103, (1947) by J. H. Crompton.)

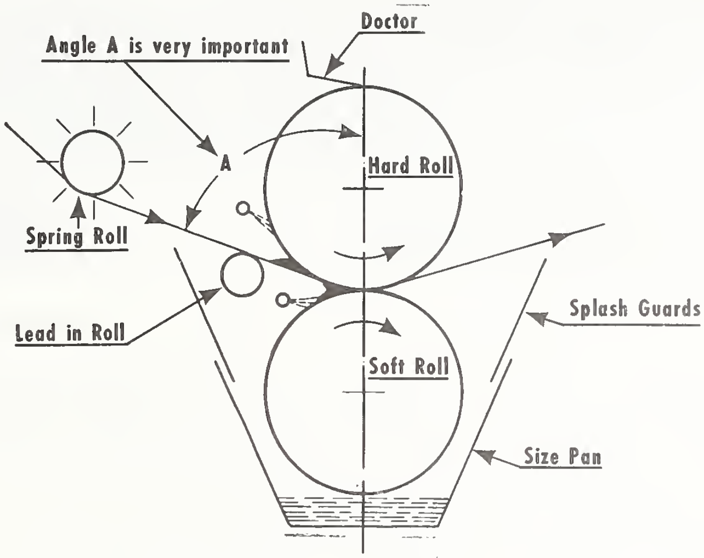

Figure 3. Application of sizing--conventional sized press.

But solubilizing the gluten is not the only change which must be effected if wheat flour is to serve as a paper size or coating adhesive. The starch component must be broken down so that flour solutions of the required concentration for paper sizing will neither be too viscous nor too fluid for proper application.

We have done a great deal of work at the Northern Laboratory on chemical modifications of flour and their evaluation in papermaking. One of the most economical to carry out, and therefore important to investigate thoroughly, is the reaction of flour with acid. Figure 4 illustrates the effect of acid on the flour properties of a flour-water mixture that has been heated to the boil, then cooled. Untreated flour, shown at left, forms a stiff gel at 5 percent concentration, whereas acid-treated flour flows readily. Viscosity is only one criterion of a satisfactory surface size; properties of the sized paper also are of prime importance, and these can be determined only by applying the modified flour to paper and measuring its tensile strength, fold endurance, bursting strength, brightness, etc. Indeed, the best evaluation of a paper additive is a trial run in a large-scale, high-speed commercial production machine. Since this obviously is not feasible in the developmental stages, we must rely on results obtained with small-scale, low-speed laboratory and pilot-plant equipment.

Let me illustrate our progress on acid-modified wheat with figures showing some of the equipment used in modifying the flour and applying it to paper, as well as some of the test results. Optimum conditions for acid treatment were worked out in a small sigma-blade mixer. This mixer accommodates about

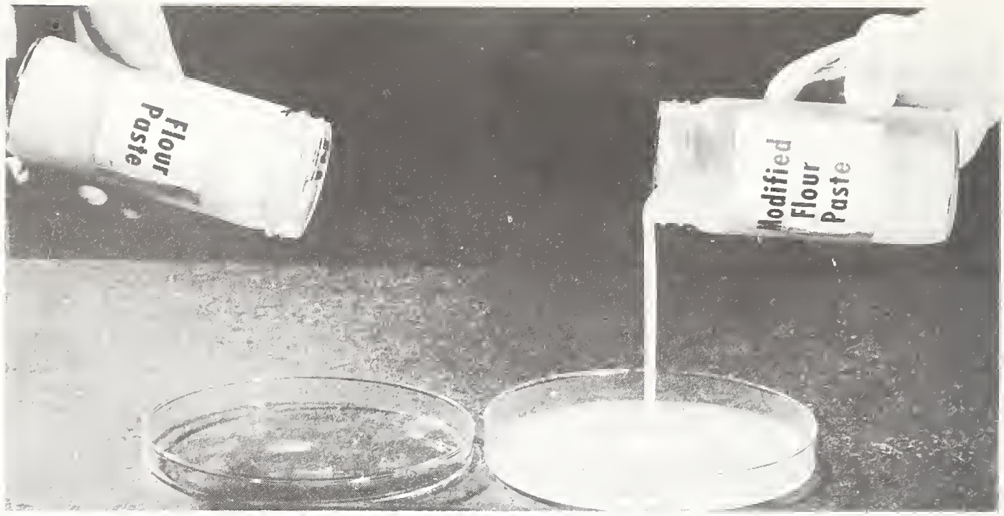

Figure 4. Flow property of acid-treated flour-water paste.

1-pound batches of flour, adequate for tests of solubility and viscosity and for evaluation as a paper size when applied by a small laboratory-size press to the surface of paper. The most promising products also were evaluated by machine runs on our small 10-inch Fourdrinier papermaking machine (Fig. 5). A pulp slurry enters the far end at the left where it first goes onto a moving screen

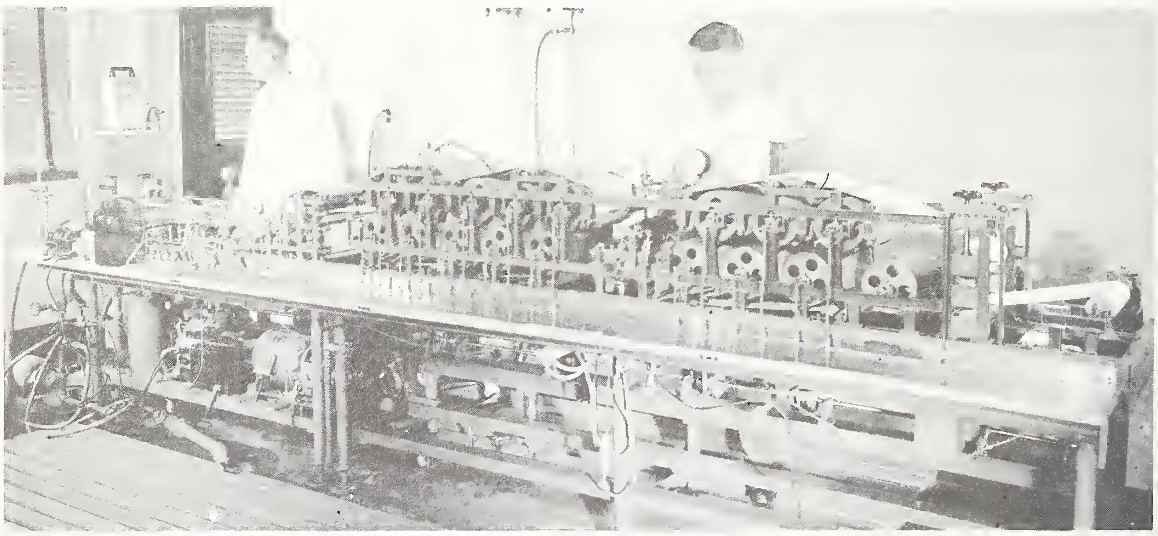

Figure 5. Ten-inch Fourdrinier machine used in Northern Utilization Research Laboratory.

belt, loses water, and forms a wet sheet. This sheet is picked up on a moving felt that supports the paper on its way over heated rolls in the drying section of the machine. About midway along the length of the machine, the dried sheet passes through a size bath; passage over the heated rolls comprising the right end of the machine dries the paper and it is then wound in a roll at the extreme right.

Although this small Fourdrinier machine, which operates at a paper speed of 10 feet/minute, gives some information on the behavior of a new size, it is most desirable to test the size on a higher-speed machine and operate for long periods. We have been fortunate to have the cooperation of the Forest Products Laboratory in testing our cereal products on their 18-inch Fourdrinier, which operates at paper speeds up to 300 feet/minute. Because this machine requires approximately 10 pounds of modified flour for a 2 to 3 hour run, we had to devise larger equipment for making the acid-modified flour. Figure 6 shows a ribbon mixer with a capacity of 30 pounds of flour adapted to this purpose. Concentrated acid is introduced through a spray nozzle and heat is controlled by the steam jacket.

Figure 7 shows the Fourdrinier machine at the Forest Products Laboratory and provides some basis for judging the size of the equipment required. After passing over the screen and losing most of its water, the paper sheet is dried on heated rolls, then passes over the size rolls (Fig. 8) where the modified wheat flour is applied.

Strength properties of paper sized with acid-modified flour are presented in Table 6. Comparison is made with both unsized paper and paper sized with hypochlorite-oxidized starch, one of the best commercial products now used for sizing paper. The acid-modified starch compares favorably with the commercial

Table 6. Properties of paper machine-sized with modified flours

Sizing agent	Tensile strength: Breaking length, meters	Tensile strength: % Increase	Burst: g. cm.^{2}/g.s.m.	Burst: % Increase
Unsized control	6470	-	17.6	-
Commercial oxidized starch	7740	20.1	25.3	43.8
Acid modified wheat flour	8000	23.3	25.0	42.0
H.E. acid modified flour	7960	23.0	23.9	35.8

starch in strength properties of the sized papers. The last line lists the properties of an acid-modified starch that was subsequently reacted with ethylene oxide. This treatment improved the dispersibility of acid-modified flour in water and its pick-up on paper from the size bath with corresponding increases in strength properties. Both the acid-modified and the hydroxyethylated acid-modified flours appear suitable for paper sizing so far as strength properties are concerned.

Viscosity properties of the modified flours are superior to those of acid-modified starch with respect to retention of fluidity at 55°C., the temperature of the size bath, or when cooled from 55° to 25°C., i.e., room temperature. Viscosity properties have been satisfactory in relatively brief machine runs, but much longer runs should be made to determine whether undesirable viscosity increases occur in the size bath due to selective absorption of a flour component.

Figure 6. Ribbon mixer used in preparation of acid-modified flour.

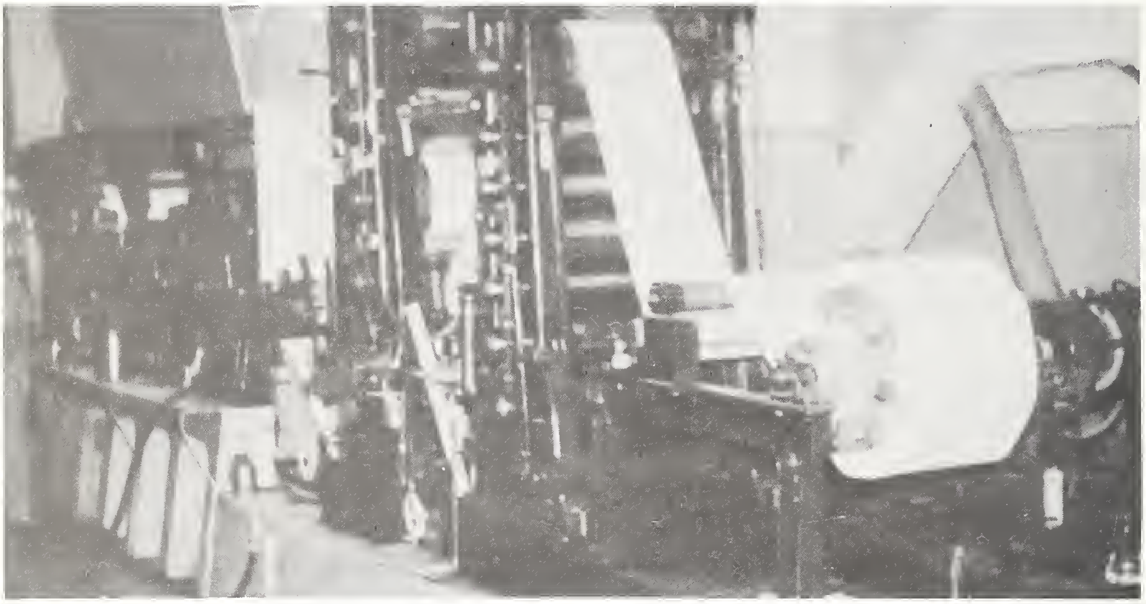

Figure 7. Eighteen-inch Fourdrinier machine in the U. S. Forest Products Laboratory.

Figure 8. Rolls used to apply modified wheat flour sizing.

Acid-modified flours, after reaction with ethylene oxide to produce the hydroxyethylated acid-modified flours, compare favorably with commercial products as coating adhesives. Adherence of the coating to the paper as measured by the Dennison wax-pick test, and the I.G.T. printability test (Fig. 9) is as good for wheat flour products as for commercial hypochlorite-oxidized starch.

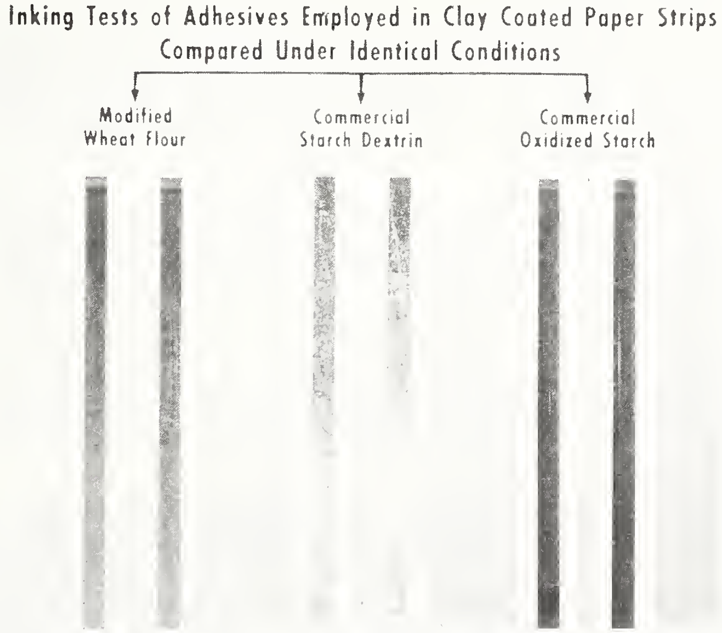

Figure 9. I.G.T. printability test results.

Although the acid-modified flours have been investigated most extensively, several other chemical reactions are being explored in our Laboratory to change the properties of flour. Among these is the sulfation reaction in which an electrically charged sulfate group is introduced into flour by reaction with sulfur trioxide. Properties of the flour depend on the number of sulfate groups introduced; at relatively high levels of substitution, the sulfated flours have unusual thickening power when dissolved in water (Table 7). Sulfated wheat flour exceeds carboxymethyl cellulose, a commercial thickening agent, in the viscosity it gives at 2-percent concentration.

Table 7. Comparative viscosity of wheat flour sulfates and related materials.

Product	Viscosity Cps.	pH
Sulfated wheat flour[a]	4360	6.5
Sulfated wheat flour[b]	900	5.8
Sulfated wheat starch	1580	6.1
Unmodified wheat flour	30	6.1
Carboxymethylcellulose (MVT)	750	6.9
Sodium cellulose sulfate	229	6.8

a/ 12 hr. reaction. b/ 48 hr. reaction.

Other potentially valuable properties of sulfated flours are the clarity of their solutions and the completeness with which they disperse in water.

Preliminary tests indicate that these new flour derivatives have promise as an internal sizing agent for wet-end addition in papermaking.

<u>Cereal xanthides</u>. Outstanding properties of both cereal grains and their principal components, starch and protein, are their swelling and dispersibility in water. The many and varied food, feed, and industrial uses to which cereal products are put depend in part at least on this behavior in water. But for many industrial uses we should like to convert cereal products to water-resistant materials--materials that would permanently retain their strength when immersed in water, and, ideally, would be stable dimensionally when wetted or exposed to variations in ambient humidity.

As discussed earlier, the reactive aldehyde groups in dialdehyde starch form linkages with other groups (hydroxyl groups) of cellulose, proteins, or starch, which bind the molecules together and resist dispersion by water. These linkages, however, are not permanent in character and gradually are broken in water. Although many chemical reactions would lead to permanent bonds between adjacent starch or protein molecules, few meet the requirements of cost and conditions of application that were set by the papermaking applications we had in mind.

A linkage of particular interest was the sulfur-sulfur linkage which crosslinks adjacent molecules in many proteinaceous materials. As illustrated in Figure 10, the -S-S- bond can be broken by a reducing agent which adds a hydrogen atom to each sulfur atom. The crosslinkage can be restored by reaction with an oxidizing agent. An example of the properties imparted to a protein by the -S-S- bond is the elasticity of wheat gluten. This unusual property of a vegetable protein is familiar to everyone who has made chewing gum by masticating a mouthful of wheat. If the -S-S- bond is broken in wheat gluten, its elasticity is destroyed and the swelling and solubility behavior of the gluten is greatly changed. Another familiar example of the properties of the -S-S- bond

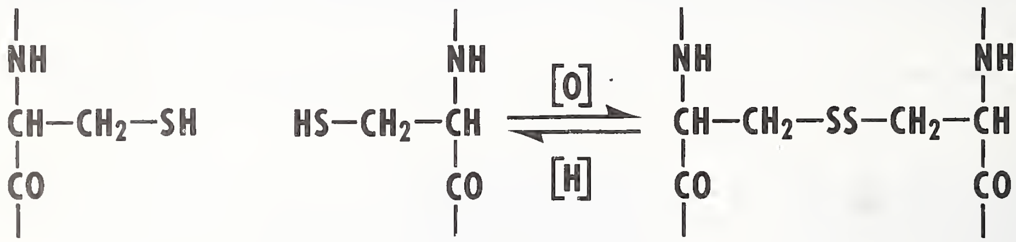

Figure 10. Crosslinks in proteins.

is found in hair, which owes much of its insolubility and dimensional stability in water to crosslinking of adjacent protein molecules by the disulfide bond. Permanent waving is accomplished by an initial breaking of the -S-S- bonds. This allows one molecule to slip by another and the hair to be deformed readily. The beautician then bends the hair into the desired shape by winding it on mandrels under tension. Finally the -S-S- bonds are reformed by application of an oxidizing agent that fixes the structure of the hair fiber in the new shape, and the hair has been permanently waved.

The reaction we employed to introduce -S-S- crosslinks between adjacent molecules in starch, flour, and other cereal products is shown in Figure 11. It involves the reaction of starch, here designated as ROH, with sodium hydroxide and carbon disulfide. Sodium hydroxide is familiar as lye, and carbon disulfide is an inflammable, fairly volatile liquid. The product of the reaction, called starch xanthate, is soluble in water, which makes it convenient to handle in solution. On treatment with an oxidizing agent, such as chlorine or hypochlorite, two starch molecules containing xanthate groups react to form the -S-S- crosslinkage between them, the product being called a xanthide. Starch xanthide swells but is insoluble in water, and its swelling decreases as the number of -S-S- linkages is increased.

$$\mathrm{ROH + NaOH + CS_2 \longrightarrow \underset{xanthate}{ROCSSNa}}$$

$$\mathrm{2\ ROCSSNa + Oxidizing\ Agent \longrightarrow \underset{xanthide}{ROC(=S)S{-}SC(=S)OR}}$$

Figure 11. Preparation of xanthates and xanthides.

The solubility of xanthate in water makes it simple to introduce it into a wood pulp slurry in a form which gives maximum opportunity for each wood fiber to be coated with a layer of the starch product. To make paper containing cereal xanthide, a solution of starch xanthate is stirred into a wood pulp slurry; after the xanthate is uniformly distributed, the insoluble xanthide, called cereal pulp, is formed upon addition of an oxidizing agent. The result is a slurry of wood pulp fibers enmeshed in a coating of starch xanthide. The mixture is then fed to the paper machine and the starch or other cereal xanthate becomes an integral part of the paper sheet. Figure 12 outlines the complete sequence of operations.

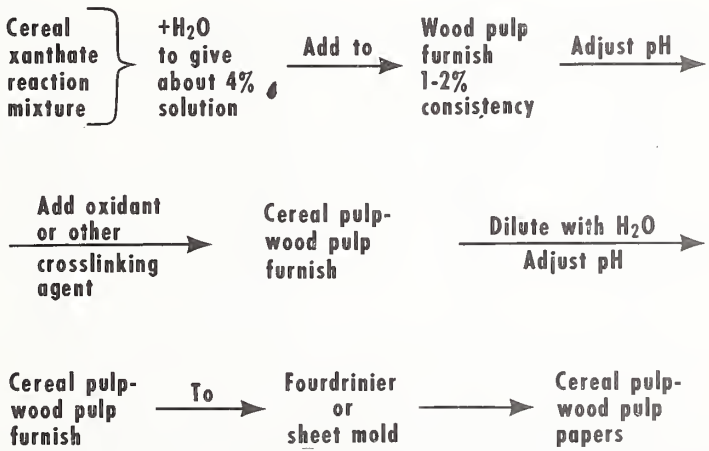

Figure 12. Incorporation of cereal xanthate in paper.

Properties of the papers containing cereal xanthides are presented in Table 8. In papers made with unbleached sulfate pulp, 7.6 to 13.2 percent

cereal pulp was incorporated as the xanthide of wheat starch, wheat bran, or finely ground whole wheat. In all cases, the burst and wet strengths were improved by the cereal pulp, the wet strength from 4- to 6-fold, and the dry strength was decreased, at most, only slightly. Effectiveness of a metal salt, $ZnCl_2$, in forming a -S-Zn-S- linkage between starch chains, is shown by the results given in the lower part of Table 8.

Table 8. Properties of Fourdrinier papers containing cereal xanthide

Xanthated material	Xanthate[a/] per 100 g. wood pulp g.	Cross-linking agent	Cereal pulp in O.D. sheet %	Burst factor	Breaking length, m. Dry MD	Breaking length, m. Wet MD
Unbleached softwood sulfate pulp--S.R. freeness, 700 ml.						
None	None	--	--	43	9480	350
Wheat starch	50	I_2	13.2	48	9000	2260[b/]
Ground whole wheat	10	I_2	7.6	46	8730	1350
Wheat bran	10	I_2	9.8	46	8900	1980
Bleached softwood sulfate pulp--S.R. freeness, 700 ml.						
None	None	--	--	59	11,800	300
Wheat starch	10	$ZnCl_2$	2.3	58	11,720	1030

a/ As O.D. unxanthated starting material. b/ Wet strength after 24 hr. soaking was 2180.

Effect of incorporation of larger amounts of cereal pulp in paper in the form of wheat starch xanthide is shown in Table 9. Dry and wet strengths were as good as or better--especially wet strength--than that of the control paper containing no starch xanthide for all levels of addition, which ranged from 1.1 to 39 percent of the weight of the oven-dry sheet. Burst and tear strengths were as good as the control paper for cereal pulp content of 33 percent and below; tear strength and opacity were affected adversely by incorporation of starch xanthide, and diminution of these properties occurred somewhere between 3.6 and 19 percent addition.

Table 9. Properties of handsheets containing starch xanthides

Xanthide in O.D. sheet %	Burst factor	Tear factor	Schopper fold double	Opacity %	Drop test sec.[a/]
--	57	152	1020	68	115
1.1	65	142	1120	71	239
1.5	65	134	1350	68	281
2.8	68	125	1220	64	336
3.6	61	148	1130	70	216
19	71	72	2900	45	600+
24	66	82	2040	53	600+
33	56	77	1750	52	600+
39	44	82	690	66	600+

a/ Time in seconds required for a drop of water to be absorbed.

Among other desirable properties of incorporation of cereal xanthide in wood pulps is the improvement it effects in drainage rates of highly beaten wood pulps, such as those used in making greaseproof paper. As shown in Table 10, addition of 28-percent starch xanthate to a pulp with a drainage time of 107 seconds results in a drainage time of 36 seconds; similar addition to a pulp with a 52-second drainage time caused a reduction to 30 seconds. Importance of a short drainage time lies in the greater speed at which a Fourdrinier machine can be operated.

Table 10. Properties of greaseproof paper handsheets containing cereal pulp

S.R. freeness of bleached sulfite wood pulp ml.	D.S. of starch xanthate	Starch xanthate[a/] per 100 g. wood pulp g.	Xanthide in O.D. sheet %	Pulp drainage time sec.	Burst factor	Tear factor
250	--	None	None	107	37	29
250	0.20	40	29[b/]	36	39	23
500	--	None	None	52	62	51
500	0.04	50	23	30	63	45

a/ As O.D. starch. b/ Crosslinked with iodine, the other xanthate crosslinked with chlorine.

The results reported above on papers containing cereal pulp were obtained with handsheets prepared in the laboratory. The cereal pulps were prepared in beakers. The various ways in which the reactions have been carried out as well as the many operations and techniques employed have not been those required for large-scale operation, but were designed for laboratory testing. The results are most encouraging, and we are now engaged in translating laboratory results to the pilot plant. We must continue laboratory work, however, since we need more information on the chemical reactions that occur, in addition to the principal reaction, and how to control or prevent them.

One problem of large-scale operation is development of a method for preparation of the cereal xanthate. We have a commercial machine, designed for mixing plastics, which seems reasonably satisfactory. We do not necessarily consider it the best available, but it works. Using this machine, we made enough cereal xanthate for larger-scale machine runs. After the xanthate was made, it was dispersed in water and transported to the point of testing in solution. The last of our figures is a photograph of a recent run on the paper machine at the Forest Products Laboratory in which paper containing 10 percent wheat starch xanthide was made for one page in the first issue of WHEAT ABSTRACTS. As you may know, WHEAT ABSTRACTS is published by the University of Nebraska under the sponsorship of many groups.

In Figure 13 an operator at Forest Products Laboratory is adding starch xanthate to wood pulp. The yellow color of the pulp mixture due to the xanthate was still apparent after addition was completed. However, addition of oxidant, in this case sodium hypochlorite, to convert to the starch xanthide changes the color to the white. The remainder of the papermaking operation is the same as that for conventional wood pulp. The run at Forest Products Laboratory was our

first on this machine. Problems were met in the operation, and we have many more to solve before the process can be operated on a commercial scale.

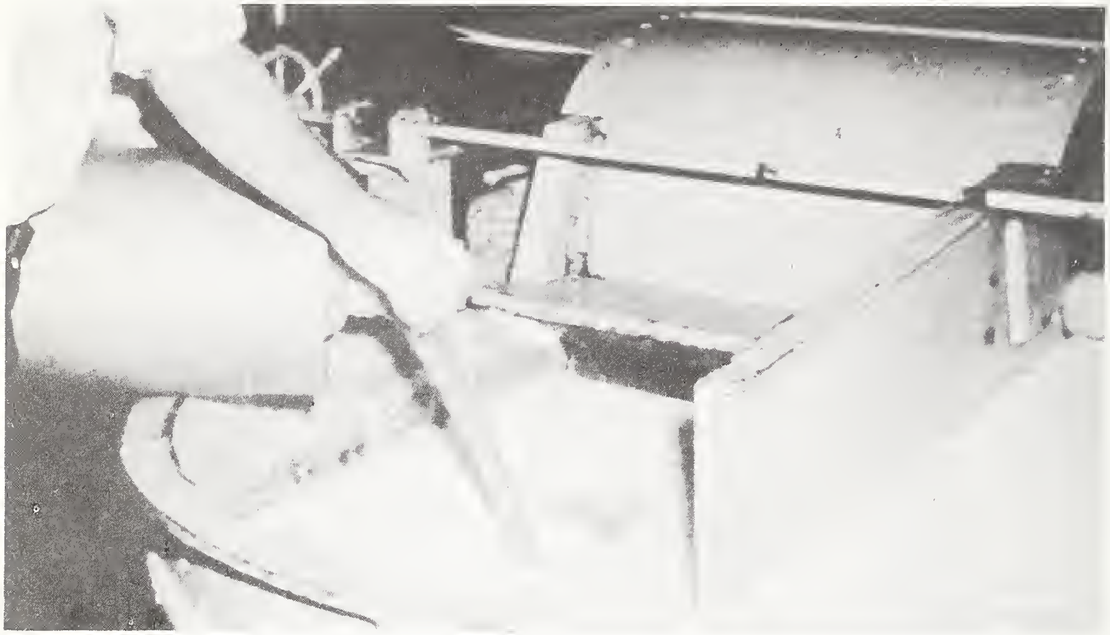

Figure 13. Addition of xanthate to wood pulp.

The two chemicals, sodium hydroxide and carbon bisulfide, cost less than 5 cents per pound, respectively, and oxidizers needed to convert the xanthate to xanthide are also relatively inexpensive. We have made preliminary cost estimates on the overall process, starting with a cereal product and including the steps needed to convert it to xanthide, and believe the process has good possibilities for commercial success. The increase in appropriation which we received this year will enable us to accelerate substantially our work on this project, and we are confident that we shall have significant progress to report to you in another year.

Discussion: The process, economics, and possible alternative raw materials for wheat in papermaking were discussed. Starch is modified by addition of hydrochloric acid in the process discussed and probably this product would be edible (although no tests have yet been run). The xanthides would probably be inedible. The costs of operations cannot be accurately predicted until larger-scale operations can be conducted. Therefore the first applications of modified cereals in papermaking will probably be for the purpose of imparting special qualities to paper, such as wet strength. Wood pulp that would be replaced in paper costs 4 to 4-1/2 cents per pound and up to 7 cents for high-quality pulp for special purposes. Whole-grain flour and starch may find cost competition restrictive but mill by-products at 2 cents a pound may even offer cost advantages. More work is to be done on the use of such by-products in papermaking. In respect to other cereals, it appears that straight cost comparison on the basis of starch content is involved. Research is still under way to determine whether quality of wheat protein imparts any specific advantage in favor of wheat. Although the xanthates are smelly during processing operations, the chemical linkages formed are stable and the paper produced is free from bad odors.

QUALITY REQUIREMENTS OF DOMESTIC BAKING INDUSTRY

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Before discussing specific quality requirements of the baking industry, I would like to build a brief background that I feel is essential if we are to understand each other and the magnitude of the problem. Meeting the quality requirements of the domestic baking industry is not a simple problem. When we consider that no one set of quality conditions fits all the needs and the various sectional consumer preferences, not to mention mechanization and process differences and individual baker preferences, we immediately enter into a complex realm of extremely difficult requirements.

Gentlemen, breadmaking is a much more complicated process than making steel or cracking crude oil. This statement was made a few weeks ago to a meeting of bakers at the American Institute of Baking by no less a personage than Dr. Henry Borsook of the California Institute of Technology. In breadmaking we are not only confronted with chemical and mechanical processes, we are also confronted with the life process itself, known as fermentation.

As further background let us next discuss why bakers must insist on quality flour and other ingredients. The answer is simple economic necessity motivated by consumer demands.

The baking business is a highly competitive business in itself, not to mention competition from literally hundreds of different foods. The competitive position of the baking industry with other foods depends largely on the inherent quality of its baked products. Without good-quality flour the baker cannot produce the kind of bread and other bakery products the consuming public demands. Make no mistake about it, the opinions of the individuals who may be producing the wheat, or milling the flour, or baking the bread mean nothing whatever at the point of sale, which is the grocery store. The determining factor is the consuming public. They dictate what the baker will make and the quality he must have to meet their demands.

What is quality? With a background of complex quality requirements and the knowledge that the baking process is complicated, let us now attempt to answer a really difficult question. What is quality? Webster defines it as any character or characteristic which may render an object good or bad, commendable or reprehensible.

Basically, quality is people. Quality in baked goods is the plant breeder and the agronomist and the experiment station personnel. Quality is the researcher in the laboratory at Beltsville, Maryland, Peoria, Illinois, or Albany, California, as well as the researcher at a state college or the American Institute of Baking or some private research establishment. Quality is the farmer who plants better wheat varieties so as to produce better quality.

Quality is the grain handler who takes the time and money to separate good from poor wheat. Quality is the miller and the baker and mother nature. Quality is all of us.

HARD WHEAT FLOUR

Now, let us review the specifics of hard wheat flour quality desired by bakers for white pan bread and similar products.

Conventional white pan bread. Wheat quality, as it relates to flour for the commercial production of white pan bread, is determined by gluten quality. What is gluten? Gluten is what is left after you wash the starch away from wheat flour. Bread, for example, is made as a result of fermentation and the holding of gas produced in the process of fermentation by the gluten content of the flour. (Wheat is the only grain that has gluten in any appreciable quantity.) Good quality gluten has elasticity. It is not too tough to stretch and not so weak and brittle that it breaks. Without good quality gluten that has proper strength, pliability, and elasticity, the baker cannot make a product that will satisfy the demands of the consumer. Good-quality gluten produces bread with good volume, good color, and a strong, bright but soft crumb, all of which are primary quality requirements in a loaf of bread and important to the consumer. Thus good-quality gluten is the determining factor in wheat and flour quality and the one most important quality requirement for making white pan bread in a mechanized bakery.

The next most important requirement for white pan bread is uniformity day in and day out. One requirement of mechanization and automation is that you must have a set schedule, a set formula, a set list of production methods and the production must continue within these restrictions at high speed without stops to make adjustments for variations in flour or other ingredients. High-speed machines show up bad characteristics which the practical "know how" of the "old-time" baker might otherwise disguise or modify. Today there is no time to disguise or modify.

The advent of bulk flour also multiplies the need for uniformity because the economics of bulk flour necessitates minimum storage. All too often a shipment of flour is used up before laboratory tests can be completed or adjustments made in the bake shop. Additional general quality requirements call for a clean flour with good color and a low fragment and rope-spore count.

Continuous-mix white pan bread. Although quality requirements for continuous-mix bread are much the same as those required for conventional bread, the advent of the continuous-mix method has focused much attention on flour requirements, particularly as regards strength and quality for this type of bread-making process. At this point it appears that many flour types can be used successfully in the manufacture of continuous-mix bread--i.e., spring wheat, spring/winter blends, and straight winter wheat. The quality requirement does follow a very definite pattern as dictated by the limitations of the machines employed. Characteristics most desirable are:

1. The gluten must be mellow yet strong enough to possess considerable tolerance toward mechanical abuse, and the flour must be extremely uniform day in and day out.

2. The flour must hydrate rapidly. Work in terms of gluten development cannot take place until hydration is completed. Because drastic limitations on time are present during which the dough can be expanded to the developer head, the flour must hydrate rapidly if it is to be adequately developed.

3. Developer heads in continuous systems are of such mechanical construction that they will "shear" starch particles and "damage" them. Damaged starch is particularly susceptible to enzyme action, and excessive enzyme activity results in a wet crumb, poor crumb color, loss in bread volume, and general poor quality. The machines create starch damage, and it is most important that the flour contain minimum levels of damage. An exact level is not known. Some cereal chemists believe that the level is related, so far as tolerance is concerned, to protein content and quality of that protein.

4. The flour must respond rapidly to oxidation in a positive manner. Continuous systems require high levels of oxidation, and if the flour does not respond, it is quite possible to exceed the levels permitted by U. S. Food and Drug Administration.

SOFT WHEAT FLOURS

Soft wheat flours are milled from special wheats that are relatively low in protein and quite mellow in strength. The all-important characteristic of soft wheat (as well as bread wheats) is gluten quality. Without proper gluten quality, it is impossible to attain quality in the end product. Generally speaking, soft wheat flours fall into four types: cracker sponge, cracker dough, cookie and cake.

Let us consider the cracker flours first. The cracker baker attempts to produce a light, flaky cracker with good color and appearance. The cracker must not be so mealy as to stick to the roof of the mouth. It cannot be too hard, since this results in excessive breakage. The color must be an even toasted color rather than spotty. As in bread production, so too in cracker production, flavor is produced through proper fermentation. The sponge dough method is used in cracker manufacture. Since the sponges are fermented for some 20 hours, a relatively strong flour is required. This flour is about 0.40 percent ash, 9.40 percent protein, and completely unbleached. Very little yeast is used so that the fermentation process is quite slow. Of the 20 hours required, fermentation during the first 12 is caused by action of the yeast. The last 8 hours involve bacterial fermentation. In these 8 hours real flavor is produced. At this point, the dough is highly acid. In cracker fermentation in addition to protein quality, the extent of starch damage is extremely important in maintaining uniformity in the finished product.

A cracker-dough flour is then added to the mixture along with lard, malt syrup, and some baking soda. The doughs are then fermented an additional four hours. Baking soda is added to neutralize the acidity developed in the original dough and thus ends up with a finished cracker that is slightly alkaline. Because of the shorter fermentation period, cracker dough flour is not as strong as sponge flour. Normally dough flour will be about 8.50 percent protein with an ash of 0.40 percent and completely unbleached.

As in almost everything, we find an exception to the rule. The advent of bulk handling has forced some cracker bakers to use one flour instead of two. You can easily see that if one flour is used, the need for extra bulk storage

bins is eliminated. Consequently the one flour used is really a blend of the sponge and dough flours. With these past points in mind, you can see where a cracker baker wants a flour that is strong enough to carry the excessive fermentation treatment and still mellow enough to give a tender, flaky cracker.

Cookie flours will vary from region to region, depending upon the type of cookie sold in the market. Normally speaking, this flour will have an ash of 0.38 percent with a protein of 7.0 percent to 7.5 percent. The protein is weak, as you can well understand, so as to give a good spread in the cookie. Higher protein would necessitate the addition of excessive sugar and shortening to attain the proper spread factor. While the gluten in this type of flour is mellow, it still must have good quality. As an example, the same flour is used to make sugar cookies with excessive spread, and also graham crackers, where volume is all important. If the gluten is not strong enough to produce a volume graham cracker, the consumer will not like it and it will necessitate the addition of extra crackers to fill out the box, which is expensive.

Here again, starch damage plays an important role. High starch damage tends to restrict cookie spread while low starch damage tends to increase cookie spread from a single wheat parent.

Cake flours normally run around 0.30 percent ash and 7.00 percent protein. They are highly bleached, since a very white color is desired, and for the purpose of breaking down the protein. Better cake flours will have a pH of 4.5 to 5.0. In this field we have witnessed a significant change with the advent of impact milling and air classification. In years gone by, the best cake flour was milled from low protein soft wheat.

For the retail baker of today, who uses little machinery, this flour would still be good. In a high speed commercial plant with a continuous process, many bakers feel another type flour has proved to be better. This is flour milled from hard wheat with use of the air classification system. The protein naturally is higher. By use of excessive bleach, this protein is broken down and the result is a nice appearing white cake, and yet the flour still has the basic strength to withstand the punishment of high-speed equipment.

While protein or gluten quality is important in either the soft wheat or hard wheat air-classified cake flours, one must not overlook the important role played by starch. A cake batter must rapidly achieve a predetermined viscosity (take up liquid rapidly) so that air can be incorporated in the batter and retained until heat of the oven causes the starch to gel and the protein of both flour and eggs to coagulate. If the flour produces a batter of low viscosity, it cannot retain the entrapped gases--thus cakes from such a flour are inferior.

The ability of a cake flour to produce batters with good gas retention is dependent on liquid holding capacity. Protein will absorb about 2.8 pounds of liquid for each pound of gluten present. Intact starch, at room temperature, will absorb only up to 35 percent of its weight in liquid. Damaged starch, at room temperature, will take up considerably higher quantities of liquid. It is quite easy to see that batter viscosity then will be influenced by the amount of starch damage in the flour. Higher starch damage will yield a batter with

better gas-holding properties. There is a limit, however, as to how far starch damage can be increased before other factors come into play which can have an adverse effect.

Before going on to a subject I call unsolved quality requirements, let me repeat: good gluten quality and day-after-day uniformity are the two most important quality requirements of the baking industry, regardless of the type of flour used or the product to be made from that flour. Also, in the final analysis, "Quality Is People"--"Quality Is All Of Us."

Major unsolved quality requirements. Since one of the objectives of this meeting is to provide an opportunity for us to present to the scientists gathered here our ideas and our problems, I would now like to suggest two major unsolved quality requirements with the hope that you might consider them sufficiently important to influence the character of your future research:

1. Lack of adequate methods for determining the quality of a wheat or a flour until the flour is actually baked into a loaf of bread. Although there are many good tests in this realm, there is no single test nor any group of tests so completely satisfactory that the mill or the bakery laboratory can check the flour ahead of time and guarantee the quality without actually baking the flour into bread. Baking is the only completely conclusive test that we can bank on to date, and it takes too long. We sorely need a reliable quick test. This is a project we would like you to do much more research on.
2. The other major unsolved obstacle concerning quality requirements of white bread is our inability to greatly retard the staling process. We have made some advances in causing bread to stay softer a few days longer than it did in the old days. However, it is a fact that softness does not necessarily mean freshness; and it is therefore possible to have soft bread that has developed a stale flavor or odor. The staling problem is far, far from being solved. In my opinion, the answer will not be revolutionary nor will it be determined by one man in a blaze of glory in the way that Lindbergh flew the ocean. Rather, I think this will be an evolutionary development that we will gradually work out through the cooperative efforts of many people in many laboratories and experimental bake shops. But nevertheless, when it is worked out it will mean better quality for the consumer, increased consumption of bread and wheat, and an economic saving for all concerned.

Conclusion. Although not directly related to my assigned subject, I would like to make a few concluding remarks that, in my opinion, are pertinent to the broad objectives of this meeting.

There comes a time in every man's life and in the life of every industry or business, when suddenly they are confronted with the fact that the job they have been doing, however good it might have been, is not one-half good enough for the future they have to face. "Agribusiness" is in that position right now, and that is the reason this meeting and others like it are being called.

Lest we forget, we should be reminded that all the drive in the world is lost if it is misdirected. Let us hope this meeting and others like it will provide the vehicle for the farmer and the scientist, for our government agencies and the miller and the baker to learn the facts first, and then, and only then, determine from these facts what is needed. Once we determine and define what is

needed, let us set out with renewed determination to find the answer so that "agribusiness" can and will continue to grow and prosper.

This country cannot afford a depressed agriculture or depressed businesses associated with agriculture. To have a strong national economy, history has proved time and time again we must have a vigorous and prosperous agriculture and businesses associated with agriculture. Make no mistake about that. This may not be an "oxygen-tent" situation; but it is darn close to it.

Let's see to it that proper amounts of money are allotted to the task ahead, instead of allowing the budget cuts on research and consumer education that are taking place at all levels--i.e., private business, state colleges, and the various federal departments. If we are to accomplish the necessary, we need to apprise the Senators and Congressmen and state representatives of all the states of the facts, the needs, and the consequences, not just the representatives of the farm states.

Gentlemen, we are very fortunate in that we do not have to search for the "promised land." We are living in it. The time is at hand when we had better stop praying for heat and pour on the coal and start the fire, if we are to preserve what we have and "agribusiness" is to continue to grow and prosper.

Do not curse the darkness. Light a candle!

Discussion: Comments included consideration of modern equipment, flour quality, and testing for flour quality. The status of continuous mixing equipment in breadmaking was described as plateauing after a vigorous upward trend. There is a gradually increasing use of fine-grind, air-classified flour in breadmaking. Use of air classification is dependent upon an economical disposal of all separated fractions. In some areas such disposal is more easily accomplished than in others. Because flours differ in many respects it is not possible to set a reasonable lower limit on protein content for bread use. In some years 10 to 10.5 percent protein flours are satisfactory and in other years this is too low. Generally, the higher the protein the better the breadmaking quality but there are exceptions. Minimum protein level depends also on the equipment being used. Flour must respond to oxidation and in the continuous mixing process more oxidation is required to develop the dough. There is worry in some instances of exceeding the legal limit of improver that may be added. Absorption capacity of the flour is also important; an increase of 1 percent could decrease the cost of bread ingredients about 3 to 5 cents per hundred pounds. To measure quality in wheat, the sedimentation test gives some information but is not used by the bakers because they deal generally in flour. The mixing-type and related flour tests (Alveograph, Farinograph, etc.) are used for general screening of flours but only baking tests are considered adequate to evaluate flours.

THE QUALITY REQUIREMENTS OF FOREIGN MARKETS

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The international export movement of wheat from surplus-producing to deficit or non-producing countries has been an outstanding feature of world trade for hundreds of years. World production for export has now reached such proportions that competition for markets is keener than at any time in history. Approximately 20 percent of the world's annual wheat production moves into export channels.

The United States has been a major exporter of wheat and wheat flour since the beginning of this century, and exports have provided an increasing portion of U. S. growers' income. During the 1961-62 marketing year, the United States exported 58 percent of its total 1961 wheat production in wheat and flour. For the past two years, exports have exceeded the total domestic use of wheat for food, feed, seed and industrial use. Total exports of wheat and flour for 1961-62 reached 716.5 million bushels.

Since World War II, the United States has been the leading wheat exporter except in 1953 and 1954 when Canada took first place. The U. S. share of the world trade during this post war period has ranged from a low of 32 percent in 1954 to a high of 52 percent in both 1947 and 1957. Our share last year was 43.9 percent of the total world trade, which amounted to over 1-1/2 billion bushels.

Since World War II large quantities of U. S. wheat have been exported under various programs, principally the Marshall Plan and Public Law 480. Approximately 70 percent of U. S. wheat sales in the 1960 and 1961 marketing years have been under foreign assistance programs. Hence, while the United States is now by far the most important supplier in total tonnage to all markets, Canadian sales for dollars surpass U. S. dollar sales by about 50 percent. Herein lies the challenge to U. S. producers and all segments of the grain trade. While the enormous cost to the U. S. of feeding large populations over the world is unparalleled in human history as an act of Christian brotherhood, the facts are only too clear that as soon as recipient countries become financially able to buy wheat on the open markets of the world, they usually consider the United States as a residual supplier of filler wheat which must be priced well below Canadian, and purchase their quality requirements elsewhere.

Let me cite three countries to illustrate--The United Kingdom, Japan and West Germany. They are--in that order--the largest dollar markets for wheat in the world. All have received large quantities of U. S. wheat under the Marshall Plan and/or P.L. 480--Germany and Japan getting a large share of their post-war food caloric requirements from U. S. wheat. How are we now faring in these markets? Last year this was the situation:

Country	Total imports (1,000 bu.)	U. S. %	Canada %
United Kingdom	165,680	11	54
Japan	104,930	32	54
Germany	78,360	9	41

With the exception of Japan, where our Pacific Northwest Soft White wheat is much preferred over other soft wheat, the U. S. share of the markets is much smaller than it should be. There must be a reason. The governments and merchants in most importing countries are friendly, in fact are at times embarrassed that they don't buy more U. S. wheat. Some U. S. grain merchants say it is all a matter of price. But here again the record shows that day in and day out U. S. hard wheat is priced significantly below Canadian Manitoba No. 3 on the world markets. This leads us directly into the quality requirements of foreign markets. Generalizations are always distasteful to scientists. To avoid misinterpretation on this important question of quality requirements, I will again talk specifically about the U. K., Japan and Germany.

Wheat quality requirements of The United Kingdom. Milling in the U. K. is every bit as sophisticated as in the U. S. Mills have many different grists--or wheat blends, each designed for a particular use. Everything from a weak pastry flour to a strong baker's bread flour is milled. There is therefore a need for wheat types and qualities within each type. Wheat production in the U. K. is approximately one-third of that country's total needs. English wheat is weak, suitable for milling blends for biscuit, cracker and pastry and family flour but generally unsuited for bread flour. However, English mills are unable to channel all their indigenous wheat to such blends and must include 20 to 40 percent of this weak wheat into bread wheat blends. Beginning with a base of about 30 percent poor quality wheat the English miller then buys wheat on the world market that will produce - when blended with English wheat - a satisfactory commercial bread flour. Currently this blend contains approximately 30 percent English wheat, 40 percent Canadian Manitoba No. 2, 10 percent U. S. Dark Hard Winter No. 1 of 13 to 14 percent protein, and the other 20 percent of imported cheaper filler-type hard wheat from various sources.

You will note that the basic wheat in the blend is Canadian Manitoba. It is no higher in protein than U. S. Dark Hard Winter No. 1. It has however a reputation of dependability as a strong blending wheat which will support the weak English wheat. A comparable U. S.-grown wheat which would do the same job as Canadian is Dark Northern Spring, No. 1 Heavy, with a minimum sedimentation of 55 and 13.5 to 14.5 percent protein.

In addition to the gluten strength requirements of the mills in the U. K., there are these other expressed quality requirements:

Test weight	60 lbs.	minimum
Shrunken & broken kernels	2%	maximum
Dockage & foreign material	0.5%	maximum
Wheat of other classes	2%	maximum
Moisture	12%	maximum

A substantial revision of our Grain Standards will be necessary before we can meet the wishes of this market. The import quality requirements of the U. K. wheat market can be summarized as follows:

50 percent strong spring wheat or equivalent
15 percent Hard Red Winter, 13-14 percent protein
35 percent Hard type Winter filler wheat

In view of the imminence of U. K.'s joining the Common Market it is unlikely that opportunities exist to increase our share of this market by getting more of the "filler" wheat business. Except for the immediate future, our share of this filler wheat market is likely to decrease as the EEC embraces the U. K. and French wheat has a big advantage. Unless we are capable of competing for a share of the market now held by the Canadians it is quite unlikely we will be able to maintain or improve our position.

Wheat quality requirements of Japan. The Japanese diet is quite different from that of Western nations. Rice is the principal cereal grain with wheat far behind in per capita consumption. Approximately 50 percent of wheat consumption is noodles, cakes, and pastries and less than 40 percent is bread. Noodle flour is largely milled from indigenous wheat blended with Pacific Northwest Soft White and Club wheat and Australian. The quality needs of the noodle maker have been fairly well satisfied.

Theoretically, Japanese bread flour quality requirements should be very close to our own. The bread-baking industry is very modern with a high concentration of capacity in large bakeries located in the principal cities. Equipment is either U. S. manufactured or a reasonable copy, including high-speed mixers, traveling ovens and temperature controlled dough rooms. The industry has relatively high technical competence. In addition, the milling industry has a number of competent, well trained and educated baking technicians who service the baking industry, much the same as U. S. mills.

The Foreign Agricultural Service, together with others in USDA and the wheat industry, has been engaged in an all-out effort to market U. S. Hard Red Winter wheat in Japan. We have been reasonably successful in convincing the Japanese Government that it is in their interest to establish a reliable source of supply second to Canada for a portion of their growing bread wheat requirements. Very extensive laboratory and commercial trials of Great Plains Hard Red Winter were conducted by the mills and bakeries in Japan. The standard, or check sample, is always Canadian Manitoba, because bread-wheat mill blend in recent years has been 80 to 90 percent Manitoba. It is understandable that millers and bakers are somewhat less than enthusiastic about substituting a substantial amount of U. S. Hard Red Winter wheat for a similar amount of Hard Red Spring in their milling and baking blends. The established blend was, to them, quite satisfactory and any change would create problems. However, to change from a strong spring-wheat milling blend to one containing up to 50 percent Hard Red Winter should actually provide the baking industry with a superior bread flour. The mellowness imparted by Hard Red Winter wheat will have particular value to the large mechanized bakeries, including the one continuous bakery already in operation.

All the foregoing assumptions of expanding the market for U. S. Hard Red Winter wheat in Japan are dependent upon the availability for export from Pacific Northwest ports of good quality wheat. Such wheat should have a minimum of 45 sedimentation, a minimum of 13 percent protein, good flour-producing

ability, good flour color and low flour ash. These are similar to our own mills' quality needs, which is not surprising as their milling and baking practices are much like our own.

In addition to the quality needs of Japan for strong Hard Red Spring and Hard Red Winter, there is a market for two other qualities of Hard Red Winter and several types of White wheat. The United States is well able to supply all of Japan's needs for these qualities and types so I will briefly list them in order to complete the picture of total market needs:

1. Hard Red Winter, minimum protein 11.5 percent, termed semi-hard in Japan and used as a minor component in bread wheat blends.
2. Ordinary Hard Red Winter, used for production of bran, from which 40 percent flour is extracted.
3. Western White, protein desired not to exceed 9 percent. Used by confectioners (cake and pastry industry), biscuit (cookie) manufacturers and as a component in noodle flour blends.
4. White Club wheat. There is an increasing demand for White Club as a separate sub-class from Western White. Protein desired is under 9 percent.

Summarizing the deficit wheat quality requirements of Japan in order of economic importance would place them in this order:

1. Strong hard wheat, spring and winter, for bread baking.
2. Western White and White Club from the Pacific Northwest for noodles, biscuits, cakes, crackers, etc.
3. Lower-quality hard wheat, spring and/or winter for bran production and 40 percent flour extraction.
4. Ordinary or "semi-hard" wheat, 11.5 percent protein, for use as a minor component in bread-wheat blends.

Quality requirements of Germany. There is a very strong preference among millers and bakers in Germany for Hard Red Spring wheat. United Kingdom and Japan each produces approximately one-third of its wheat requirement, but Germany produces nearly 100 percent. However, poor quality and unfavorable weather make about 25 percent of German wheat unmillable. In recent years the German milling blend has averaged about 75 percent indigenous wheat and 25 percent imported. Home-grown wheat is weak and would generally be considered unsuitable for bread in the United States. German bakers, however, are skilled craftsmen who make the very most of their resources.

Baking in Germany is highly decentralized in thousands of small shops. Mechanization is usually limited to a slow-speed mixer. A wide variety of types and shapes of bread and rolls is made in these shops. Despite such a desirable variety and the direct availability to consumers of oven-fresh products, bread consumption is falling. Germans, like the rest of western Europe, are diversifying their diets and bread is one of the victims. Rye bread and blends of rye with wheat are still very popular though gradually losing ground to bread made from wheat flour alone.

German food laws prohibit the use of maturing or bleaching during milling or the use of most oxidizing agents in yeast foods used by bakers. Therefore, if baking results require bleaching and maturing, such wheat flour finds itself at a serious disadvantage when competing with flour which may produce suitable

bread without such treatment. United States Hard Red Winter wheat is greatly improved for bread if during milling or baking the flour is matured with an oxidant. Dough properties are enchanced and the bread score is significantly increased. This technical "response to oxidation" is no problem in the United States but is a handicap in certain foreign countries which prohibit bleaching of flour or the use of most oxidants. This is so much a problem now that we are urging Federal and State wheat quality laboratories to consider oxidation requirements when evaluating new varieties. Mr. Finney of the Hard Winter wheat quality laboratory at Manhattan, Kansas, informs me that this characteristic is definitely varietal in nature and subject to considerable influence by breeding and selection. I have dwelt on this point briefly. It is however a major quality factor influencing millers and bakers in Germany and many other markets. If the U. S. is to compete successfully against Canadian wheat in Germany, and Europe generally, we must grow more of the kind they prefer and then assure its availability for export by proper quality identification.

Germany has been one of the big wheat traders in Europe, importing various qualities of both hard and soft wheat. Most of Germany's imports have been hard wheat intended for bread but Australian and French semi-hard or soft wheats have also been imported. The grain trade is fearful that, with the implementation of the Common Agricultural Policy of the Common Market, German imports will be narrowed to Canada for strong blending wheat and France for filler wheat. The future level of German imports is uncertain. It will be strongly influenced by the level of domestic price supports finally agreed to among the Common Market countries. In the brief interval and transition period preceding this, there should continue to be some sales of U. S. Hard Winter wheat to Germany. The long run prospects, however, indicate that Germany's import quality requirements will be largely strong blending wheat for which the competitive standard is Canadian Manitoba.

The competitive position of all U. S. wheat in foreign markets would be much better if the average level of dockage, foreign material, shrunken and broken kernels and other grains were reduced to a level similar to that of Canadian exports. To be competitive in cash markets it is necessary to subsidize U. S. wheat at significantly higher levels to all buyers because of the higher level of unmillable materials it contains. The objection to the present allowable limits of such clean-out materials is not economic alone. Of equal importance is the effect they have on the market appearance of U. S. wheat and on its general reputation for quality. In the eyes of foreign millers as well as millers in the U. S., cleanliness is an integral part of quality.

One thing producers and the grain trade in the United States can and should do is to cooperate fully with the U. S. Department of Agriculture in the very comprehensive review of wheat standards now under way. Certainly a prime objective of all groups should be to sharpen the standards to enable our exporters to compete more effectively in the important dollar markets. An effective marketing tool is urgently needed to enable exporters to compete with Canadian wheat on the basis of equal cleanliness. The standards should, we believe, provide this tool.

The standards should also, in our opinion, enable traders to accumulate stocks of hard wheat of predictable bread baking strength for domestic as well as export sales. The best available tool at present to accomplish this is the sedimentation test, either alone or in combination with protein.

The Foreign Agricultural Service holds the firm opinion that the keys to an increased share of the foreign commercial wheat markets are quality and uniformity. Clean out, I repeat, is important in the evaluation of quality. The United States has the potential to become the world's best source of wheat for every possible use. Whether we reach this goal or not depends to a large extent upon the attitudes and actions of wheat producers and our own grain trade.

Discussion: It was brought out that Canada has geared its wheat marketing more to the export trade than has the U. S. Export wheat from the U. S. is what is left after the domestic trade has selected the types and quality desired. Bakers purchase the highest strength wheat for home use and the wheats of lower baking strength are generally available for export. In Canada the wheat is generally cleaned as it passes through the trade and there is no intermixing of grades. Records exist of lower grades of wheat being shipped into terminal U. S. markets and disappearing, presumably by blending into higher grades. Such practices are subject to penalty in Canada. Canada's Fair Average Quality grades are a suitable designation for foreign importers who usually want a strong wheat for blending with weak wheat flour available to them in their own countries. For example, FAQ Manitoba No. 2 will range from less than 13 to 15 percent protein and have a sedimentation value of about 65. While this grade is useful in export trade U. S. FAQ spring wheat wouldn't be, because domestic bakers would screen off the better lots and the average quality of export wheat would have much lower average quality. The sedimentation test is growing in importance in the export trade. Some European imports have been made on this test guarantee. As yet, no premiums are being paid for such quality specifications. A premium is paid in Europe for Manitoba with a 65 sedimentation test.

OPPORTUNITIES IN INTERNATIONAL TRADE

Clifford R. Hope
President, Great Plains Wheat, Inc.

Wheat has long been important in international trade, and during recent years this trade has expanded substantially. In the marketing year 1951-52, world trade in wheat and its products amounted to 1,066 million bushels, a record. Trade was less in the immediately succeeding years but in 1955-56 reached 1,065 million bushels and in 1956-57, the figure was 1,328 million bushels. After a 10 percent decline in 1957-58, the figures in succeeding years were as follows: 1958-59, 1,321 million bushels; 1959-60, 1,328 million; 1960-61, 1,522 million, and in 1961-62 an estimated 1,670 million. The United States has shared materially in this increase with record-breaking exports of 662 million bushels in 1960-61 and an estimated 717 million in 1961-62.

The increase of world trade in wheat reflects the demands of an expanding world population. This expansion is expected to continue. According to the projections of experts, world population which stood at 2,500 million in 1950, will reach 6,300 million in the year 2000. This poses many questions, not the least of which is how these billions of people are to be fed.

In recent years, world food production has just about kept up with the population increase, but in general the greatest per capita increase in food production has occurred in the nations which are already well fed. In many of the nations where malnutrition exists, per capita production has either declined or remained stationary. This would indicate that for the immediate future at least, and perhaps for a much longer period, even the minimum food needs of the present food deficit countries can be met only by increased shipments from the present exporting countries, principally the United States, Canada, Australia, USSR, and Argentina. In both 1960-61 and 1961-62, the United States supplied approximately 43 percent of these shipments.

Our ability to continue to supply a large proportion of the world's wheat is indicated by the fact that with the possible exception of Russia, this country has the largest area in the world capable of producing wheat. This includes the Great Plains with its already immense production of hard wheat, both winter and spring, and the Pacific Northwest with its white wheat. In both areas, production can be increased substantially if markets are available.

Any consideration of potential exports from the United States must take into account the fact that two-thirds of our exports in recent years have gone out under concessional sale programs, principally those included in Public Law 480. A continuation of wheat exports at or near present levels depends upon continued extensions of this law, since it is not expected that the countries which have been recipients thereunder will be in a position to buy any substantial quantities of wheat in normal channels of trade during the next few years. There seems to be little doubt of such extensions unless marked changes occur in the world economic and political situations. In view of this, it should be

understood that my comments today are based upon a continuation of our concessional programs and little or no change in the present policy of other exporting countries of making practically all sales through normal channels of trade.

Public Law 480 has two principal purposes. One is the disposal of surplus agricultural commodities through the use of foreign currencies, barter, and grants to friendly nations in areas where dollars are scarce or non-existent. Recently, the extension of long-time dollar credits has been included in this program.

The other principal purpose is to develop permanent export markets for U. S. agricultural commodities in normal channels of trade. This is a long range program and is the basis for the worldwide market development activities which are being carried out by the Foreign Agricultural Service and a number of agricultural commodity organizations, including three representing wheat and wheat products.

The ultimate objective of these wheat marketing activities is to develop dollar markets for U. S. wheat and wheat products, keeping in mind that some of our dollar markets of today were concessional markets a few years ago and that some of the P.L. 480 countries of today will gradually become dollar markets as their economy develops.

While conditions appear favorable for increased world trade in wheat, and while the United States has certain competitive advantages, it is well to point out that we have certain handicaps also which must be overcome. One of these is our lack of experience in the export field. While the United States has traditionally been an exporter of wheat, we have not until quite recent years approached the matter seriously and systematically. We have not consistently and purposely produced wheat for export. Our marketing system has been geared to the domestic rather than the export trade and our traditional methods of grading, handling and merchandising in this country do not accommodate themselves readily to export programs.

Our principal competitors in the world market have long been interested in exports. The major part of their wheat goes into the world market. They have carefully studied this market and produced the kinds of wheat that are in demand. Exporting wheat is considered to be in the national interest, and government and trade policies are shaped accordingly. In some countries, wheat exports are a government function.

One problem common to all exporting countries is trade barriers. I suppose there is no commodity in international commerce which suffers as much from trade barriers as wheat and its products. Practically every importing country grows some wheat. It would like to grow more. It is concerned with the interruptions to commerce which might result from war. Its own wheat producers demand protection from cheaper exports.

The establishment of the Common Market area in Western Europe has made the question of trade barriers particularly important inasmuch as the agricultural policies adopted so far indicate a strong protectionist trend. Since Western Europe is our greatest dollar market for wheat, we must take every step

possible to prevent its loss or diminution. The trade bill recently passed by Congress gives the President considerable bargaining power in dealing with foreign countries on trade matters, and should be helpful if used on behalf of freer trade in wheat and other agricultural commodities between the United States and the Common Market countries. In this matter, it will probably be to our interest to work with other exporting countries.

Because of our national lack of interest in exports in the past, there are several steps which need to be taken if we are to hold and expand our position as dollar exporters in the world market.

Transportation rates from the Great Plains to water transportation have been one of our handicaps. Recently, export rates from Colorado and the western parts of Kansas and Nebraska to Pacific Coast ports have been reduced by some railroads from 98-1/2 cents per 100 pounds to 70 cents. Substantial reductions have also taken place in rates to the Gulf. The 70 cent rate to the West Coast has made it possible for our hard winter wheat to compete in Japan with Manitobas and has opened a new dollar market there for 20 million to 25 million bushels of U. S. wheat initially with the prospect of increased takings in the future. Efforts are being made to secure a 70-cent export rate from the Dakotas to the West Coast, which will enable us to hold our spring wheat market in the Philippines now menaced by Canadian competition. Because of the great distance of most of the plains area from water transportation, this matter of reduced freight rates is of the utmost importance and must continue to be the subject of continued activity.

More must be done in the way of producing the kind of wheat demanded by buyers in the importing countries. White wheat from the northwest has an excellent reputation in the markets where that kind of wheat is in demand. The soil and climate of the Great Plains produce winter and spring wheat of excellent milling and baking quality. However, there is considerable difference in quality between varieties and constant work needs to be done by agronomists and plant breeders to make wheat of the kind wanted in dollar markets available for export after domestic needs are satisfied. In other words, market development must begin in the test plots and on the farms.

Research on new wheat products is an important part of market development. One important wheat product now being placed on the export market is bulgur. This is a parboiled wheat similar to a product which has been used in the Middle East for two thousand years or more. It is especially suitable for areas where flour and bread are unfamiliar and in most cases unavailable. This is particularly true in countries where the principal food is rice, since bulgur can be prepared for eating in much the same manner as rice. Likewise, it should be readily acceptable in areas where corn and roots such as mandioca constitute important parts of the diet. The variety of ways in which bulgur may be used makes it a particularly attractive product.

Western Wheat Associates and Great Plains Wheat, Inc., working with AID and voluntary agencies, are engaged in considerable activity in promoting school lunch programs in which bulgur plays an important part. In all three continents, educational and nutritional projects of various kinds are being carried out to stimulate interest in wheat foods.

Other types of wheat food which hold considerable promise especially for export are pearled wheat products, meat-like food products, and high protein dry products. Enough research has already taken place in the Department of Agriculture to indicate that they have great possibilities especially in countries where most of the population suffers from a deficiency in protein foods.

Although the United States is capable of producing and does produce wheat of excellent quality, complaints are frequently heard from foreign buyers, particularly in Western Europe, on two points. One is that the milling and baking quality of our hard wheat is not uniform and that foreign buyers have no way of ascertaining such quality under our present system of grading and marketing. The other is that our grades are based solely on physical characteristics and the spread permitted within grades covers such a wide range that buyers who depend upon official grades may receive wheat of widely varying physical quality within the same grade. Furthermore, it is frequently alleged that U. S. wheat, although meeting grade specifications, contains more objectionable matter than wheat from competing origins. This contention was borne out by the results of the sampling program conducted in Europe by Great Plains Wheat and Foreign Agricultural Service from November 1, 1951, to January 1, 1961.

Wheat samples were taken from ships arriving at London, Rotterdam, Antwerp, Hamburg, Bremen, and Emden. The exporting countries were the United States, Canada, France, and Russia, with a few scattered cargoes from other countries. Samples were taken by the Superintendence Company, an international organization highly respected in the grain trade. A total of 387 cargoes were sampled. The samples were tested in leading European laboratories and were rechecked by the United States Grain Inspection Service in its laboratory at Chicago. Volumes of statistics came out of this program.

At this time, I want to call attention to just one set of figures which show the amount of besatz in the samples from the several exporting countries. Besatz is a term used in Europe by millers and means the sum total of all the objectionable matter in wheat. Weighted averages by countries of the total besatz found in the cargoes were as follows: Canadian Manitoba, 7.8; USSR, 8.6; U. S. Soft Red Winter, 10.0; U. S. White, 12.7; U. S. Hard Red Spring, 13.1; France, 14.1; U. S. Hard Red Winter, 14.2. These figures would seem to justify the opinion of European buyers that wheat from Canada and Russia is considerably cleaner than that from the United States.

The problems I have just mentioned do not arise in the United States, because our millers buy on the basis of milling and baking tests and have the opportunity in most cases to see the wheat and learn its physical characteristics before buying it. It seems very evident to me that if we are going to compete effectively in dollar foreign markets with countries like Canada, we must revise our grain standards so as to give foreign buyers a cleaner, better looking product, described in such a way that they will know what they are getting and can tell whether it is suitable for the purpose for which it will be used.

Let me discuss one other matter. That is the attitude of the government on the question of wheat exports. While the exportation of wheat in this country is in private hands, government policy plays a large part in determining the volume of such exports. Of course, it has everything to do with the amount

of wheat going out under concessional sales. But I am referring at this time to exports for dollars in the normal channels of trade. Here, too, the government plays a vital part since no wheat can be exported without being subsidized. Whether our wheat is actually competitive depends on the amount and terms of the subsidy. Fixing the subsidy itself is a matter of mathematical calculation. But fixing the formula on which the subsidy is to be based is a matter of government policy, and it determines how aggressive we can be in pushing our product. Thus no amount of market development activity will be of much avail unless the government policy on which subsidies are based is pitched toward real competition with other exporting countries. There have been times when wheat growers have been discouraged, because it appeared to them that government policies on subsidies favored our competitors rather than U. S. wheat growers.

Now for a paragraph by way of summary. The United States has the soil, climate, and know-how to produce wheat of excellent quality sufficient for our own use and substantial exports. If necessary our production can be greatly expanded. The rapid increase in world population has expanded world trade in wheat, and this expansion will continue. Public Law 480 and the programs set up thereunder make it possible for us to export wheat to many countries not able to purchase through normal channels of trade. In view of present world conditions, special programs of one kind or another will probably be continued for sometime to come. In the meantime, every effort should be made to develop markets in the normal channels of trade. Prospects for developing such markets are good if we (1) work at market development continuously and methodically, (2) make every effort to reduce and eliminate trade barriers, (3) reduce transportation rates, (4) continue to improve wheat quality, (5) develop through research new wheat products which have an appeal in areas where wheat has not heretofore been used extensively and promote the same through research and nutritional programs, (6) revise grain standards in such a way as to enable foreign buyers to determine more definitely what they are buying, and (7) establish government policies which will encourage exports in the highly competitive hard currency markets.

CREATING MARKET OPPORTUNITIES WITH UTILIZATION RESEARCH

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(Presented by Dr. Matchett)

What can utilization research do to help expand the sale of wheat? Let's examine the potentials separately for (1) the domestic food market, (2) export food market, and (3) industrial uses.

Figure 1 shows the order of magnitude for each of these markets during 1960-61. Fifty-two percent of the total disappearance of our wheat was exported and the remaining 48 percent was used at home. The export food market is the biggest single outlet. In turn, we can break the export market into dollar sales and sales under Government programs. About 70 percent of our exports is under Government programs and 30 percent is cash sales. If we rank our markets according to size on this basis, we see that the domestic food market is the largest (500 million bushels); second, exports under Government programs; third, exports for cash; and fourth, industrial uses. The latter is included with seed and feed wheat under the heading of "other uses" in the domestic market. What about the future? Are the present orders of magnitude indicative of the future?

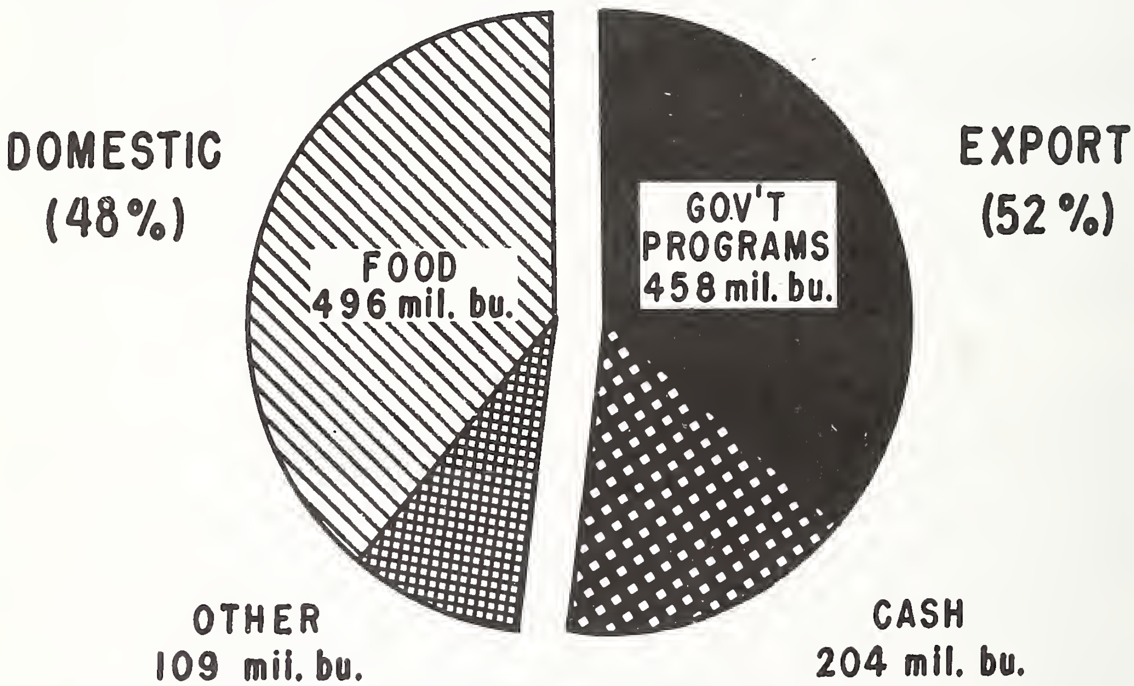

Figure 1. Utilization pattern for U. S. wheat, 1960-61.

Domestic food market. Economists paint a rather dark picture for expansion of domestic use of wheat as food. You all know the story. The demand is highly inelastic. This means that lowering the price of bread will not sell more bread or increase returns to the wheat farmer. As incomes have risen, people have eaten less bread. In fact, consumption has been declining at an average rate of 2 pounds per capita for the past 50 years. What about the future?

Let's compare wheat with potatoes. Potatoes, like wheat, have had a discouraging past in terms of per capita consumption. However, in recent years the development of new potato food products convenient to use and high in quality has stopped the decline in consumption. Such products as chips, shoestring potatoes, frozen French fries, flakes, and granules illustrate the new products responsible for this change. Utilization research has played a major role in this development. Why not do the same for wheat?

We know that as incomes rise consumers select more quality and convenience foods. The loss of flavor and aroma of freshly baked bread is an important quality factor. Accurate methods of quality measurement only now are being devised.

Undoubtedly, the loss of flavor and aroma of home-baked bread has contributed to the decline in per capita bread consumption. The adoption of the continuous dough-making process by the baking industry is making the need for flavor retention even more critical. As you all know, there has been a decided shift away from home baking. Today 96 percent of the urban and 85 percent of the rural families purchase their bread (National Food Situation, Economic Research Service, U. S. Dept. of Agriculture, Washington, D. C., May 1962, p. 23). In the mid 1920's, commercially baked bread, rolls, and sweet goods accounted for 40 percent of total flour consumption. By the mid 1950's, this had increased to 70 percent of the total flour consumption (Wheat Situation, Economic Research Service, U. S. Dept. of Agriculture, Washington, D. C., February 1962, p. 22).

Our Western Utilization Laboratory is working on the preservation and accentuation of flavor and aroma of freshly baked bread in the baking process. Substantial progress is being made in determining the nature of constituents responsible for fresh bread flavor. Knowledge of flavor constituents and factors affecting their stabilities is necessary to stabilize these critical and sensitive compounds. Success should result in improved bread and baked goods. From an economic standpoint, this could have two beneficial effects for the wheat grower. It would help increase farm return from a given amount of bread and baked products, because consumers are willing to pay higher prices for higher quality. Secondly, stemming the decline in per capita consumption would enable wheat consumption to expand as population increases. If we could halt the decline, the annual increase in population would utilize 8 million additional bushels of wheat each year. It would be a cash market not subject to import quotas or tariff restrictions.

We have only begun to explore new wheat products possible from air-classified wheat flour. Higher and lower protein fractions more uniform in composition and particle size offer interesting possibilities for new or improved

wheat foods. New and improved potato products stopped the decline in per capita potato consumption; perhaps new and improved wheat foods from air-classified wheat flour could do as much for wheat. In any event, we should take advantage of the desirable properties inherent in wheat and make them available to consumers in attractive and convenient forms.

Export food markets. There are significant differences between the problems associated with wheat exports to dollar-market countries and exports to low-income countries. In the dollar markets such as Western Europe, consumer incomes have been rising and per capita wheat consumption has been declining. In contrast, per capita wheat consumption increases in low-income countries as incomes rise. In addition, there are differences in type of products demanded between dollar-market and low-income countries.

Western Europe is our largest cash export market. Over one-third of our cash wheat sales are made here. In 1960-61, 48 percent of our total cash sales went to Western Europe. Recent studies indicate that the trend toward greater self-sufficiency of wheat in Western Europe will curtail total imports and encourage imports of Canadian wheat at the expense of U. S. wheat. In addition, Common Market country regulations prohibit the use of oxidizing agents in flour, which are essential in utilizing the protein strength of U. S. hard red winter wheats. Utilization research can contribute to the competitive position of U. S. wheat by: (1) developing strong bread doughs without additives; (2) developing dough strengthening methods acceptable to Common Market countries; (3) developing high-strength blending ratio flour fractions from U. S. air-classified wheat flour.

We can illustrate the problem of U. S. wheat exports to Western Europe from the situation in West Germany. Domestic production of wheat in Germany has been increasing until now it exceeds domestic food consumption. Total imports have decreased as domestic production increased, but not as much. The use of wheat for feed has increased. This is the result of increased domestic wheat production, which has poor bread-baking strength. Note also that the total wheat consumed for food has been declining. Apparently the rise in per capita incomes in Germany is reducing per capita wheat consumption, as in the United States. A matter of even greater concern to the U. S. wheat grower is the decline in his share of German imports.

The U. S. share of German wheat imports has dropped from around 40 percent in 1955, 1956, and 1957 to less than 17 percent by 1960-61. During this same period the imports from Canada increased from 31 to 54 percent. The higher the proportion of local wheats required to be used, the greater will be the incentive to demand wheats of higher protein level and strength. This situation can be pushed to the point where practically all imports are Canadian wheats. This has already happened in Belgium.

Western European countries grow soft wheat varieties almost exclusively. Their baking strength is poor. All the countries except France import stronger wheats to blend with local wheats. These countries as a group are capable of producing practically all of their wheat needs in terms of bushels, but not in terms of quality.

Canadian wheat provides the yardstick for high quality so far as imports into the Common Market countries are concerned. This yardstick has been clearly described in a recent study, "Germany's Need for Quality Wheats," by Agri Research, Inc., for Great Plains Wheat, Inc. Table 1 shows the relationship among German, Canadian, and U. S. wheats with respect to protein level, moisture content, and sedimentation value.

Table 1. German, Canadian, and U. S. wheats.

Item	German	Canadian	U. S. (2 samples)
Protein (%)	9.60	13.30	12.00
Moisture (%)	14.00	13.60	12.50
Fat acidity	25.69	22.14	26.20
Sedimentation value	16.80	55.30	34.60
Pelshenke index	21.00	40.00	30.00

These data were derived from laboratory analyses of 69 samples of wheat collected at German flour mills in the fall of 1961. There were only 2 U. S. samples and both were hard red winter wheats. There were 33 samples of German wheat and 16 Canadian. Note that the U. S. samples fell about half way between the German and the Canadian.

Table 2 shows the flour comparisons for maltose value and farinograph characteristics. Table 3 shows the bread comparisons for loaf volume and bread score.

Table 2. German, Canadian, and U. S. flours.

Item	German	Canadian	U. S. (2 samples)
Maltose value	209.00	160.60	129.50
Farinograph characteristics			
Peak time (min.)	1.11	7.36	5.87
Mixing tolerance (min.)	2.11	9.87	8.25
Absorption	55.30	63.20	60.70
Valorimeter	35.30	68.80	61.50
MTI	88.80	40.00	35.00

Table 3. German, Canadian, and U. S. breads.

Item	German	Canadian	U. S. (2 samples)
Loaf volume (cc)			
AACC	592.0	816.0	740.0
Remix	630.0	848.0	730.0
Bread score			
AACC	74.8	91.0	83.5
Remix	76.2	92.4	84.0

Blending capacity for bread-baking purposes is considered to be the most important criterion for testing the desired properties of imported wheats. Unfortunately, blending capacity has not been studied to an extent necessary to

provide a description of its most important details. At present roughly 1 bushel of Canadian or high-quality wheat is blended with 3 bushels of German wheat. Would air classification of hard red winter wheat provide a high-protein fraction which could enable the Germans to use 5 or 6 pounds of their local wheats for each pound of the imported high-protein fractions? Are there any varieties of U. S. hard red winter wheats which would make such a practice technically feasible? Secondly, if it would be technically feasible to do this, would it be economically feasible? What contribution can utilization research make to improving the competitive position of U. S. wheat in the Western European markets? Recent studies have indicated that additional soft wheat can be grown in Western Europe. It is evident that as more local wheats are consumed the demand for higher-quality imports will increase. Utilization research can make a contribution to the competitive position in dollar-market countries.

In the less-developed countries, low-cost food is important. Wheat at $2.08 per bushel supplies approximately 425 calories for 1 cent. In the Far East, Western Asia, and Africa where the average calories per day run between 2300 and 2400, 6 cents' worth of wheat at Chicago more than covers the average daily calorie requirements. If wheat were converted into flour it would become too expensive for many people in the world. It is necessary to tailor the product to the needs and customs of the country which is going to use it. The following wheat foods appear to offer possibilities for expanding exports to low-income countries:

1. Bulgur. Good storability, ease of preparation, high nutritive value, and low fuel needs make bulgur an ideal food to meet the requirements of the large mass of people in the low-income and poverty groups. Partly debranned, parboiled wheat in either cracked or whole-kernel form is well suited for use in many dishes ranging from soups through main dishes to desserts. Dry quick-cooking forms are particularly well suited for export to fuel-short areas. Though development research is well advanced on the basic dry and canned products, improved stability and rehydratability of quick-cooking or instant bulgur products are required. Further work is also needed on the processing of additional ready-to-eat items such as baked puddings and casserole dishes made with parboiled wheat. Products enriched and fortified with vitamins, amino acids, minerals, and additional protein are needed particularly for export markets.
2. Pearled wheat. Low-cost pearled wheat products are needed for countries which prefer foods with a blander taste than bulgur.
3. Fermented wheat foods. Such foods are needed for countries preferring products of these characteristics.
4. Meat-like foods from wheat. Meat-like foods from wheat are needed for countries which cannot afford meat or where vegetarian diets are used. Products similar to hamburger can be made from gluten alone or gluten mixed with whole-kernel cooked wheat and flavored according to local tastes. By combining cooked, whole-kernel, or cracked wheat with various seasonings, condiments, and spices, and binding the mixtures together with gum gluten, it is possible to form tasty low-cost meat-like products similar to smoked and cured sausages. These products are suitable for countries where people cannot afford adequate amounts of meat. Cooked whole-kernel wheat has the firm yet tender texture essential for the main body of dry smoked sausage-like products; cracked or broken forms have a texture desired in other products of a related nature.

Technological advances on these meat substitutes would stimulate their manufacture in foreign countries from U. S. wheat and glutens, aiding in establishment of new markets and stimulation of further exports of wheat. Intensive

research is needed to determine the most appropriate proportions of gluten and wheat for binding the ingredients into each type of product and for attaining the best textures, the optimum combinations of ingredients of flavoring substances, the stabilization of the more sensitive constituents, and the technical requirements for maintaining proper textures and flavors during all processing and packaging steps.

5. Wheat food for children. For countries which cannot afford milk, inexpensive high-protein wheat flours fortified with appropriate nutrients can be developed for use as a beverage for children. High-protein wheat flours might be made into a powdered product readily reconstituted in cold or warm water to form a milk-like beverage, fortified with appropriate vitamins and minerals to equal the nutritive value of milk. Inexpensive products are badly needed by the countless numbers of undernourished children in the developing countries overseas. Work on the direct phases of development of such a product from wheat is being undertaken by our Western Utilization Research and Development Division.

Industrial uses. The major constituents of wheat are starch and protein with lesser amounts of oil, nonstarch carbohydrates, and minor and unknown components. Development of industrial uses necessarily depends on utilization of properties of the starch and protein components, either isolated as the separated components or as they exist in the wheat kernel or its milled product.

Wheat gluten is a protein which is unique in its ability to form a cohesive, elastic mass when mixed with water. Although this distinguishing characteristic is utilized in producing bread and other baked goods, little is known about its special physical properties. Insufficient research has been made to exploit these properties in diverse industrial outlets. Finding new high-value uses for gluten, as is, or after chemical modification, is the key to industrial utilization of wheat.

For most purposes, wheat starch can be used interchangeably with corn starch. Potential new or expanded large-scale markets exist in a number of industrial uses. These include applications in the expanding paper, textile, plastics, rubber, and allied industries in which materials with requisite properties can be produced from starch by chemical and microbial action.

Development of new products from wheat constituents does not necessarily require their separation. Wheat flour is a raw material already commercially available in large quantity and at reasonably low cost. Flour contains both starch and protein, and treatment with chemical reagents may modify either one or both components to provide products with desirable properties for industrial purposes. Several of the more promising areas for research are outlined below.

New cereal products for paper. Wheat flour and cereal starch products recently developed at the Northern Utilization Research and Development Division can be economically incorporated as an integral part of pulp and paper. As you heard yesterday, the market potential in these outlets appears to be in excess of 100 million bushels per year.

Adhesives, coatings, sizes, thickeners, and plastic materials. Opportunities exist for an additional annual use of 1 billion pounds of flour and

starches by 1975 if research is successful in maintaining projected growth in markets now held by these products. Inroads can be made into the rapidly growing billion-pound synthetic adhesive and 9-billion-pound synthetic plastics market predicted for 1965, provided flour can be converted into new polymers having water resistance, stronger adhesion, and better adaptability to high-speed machine operation.

GLUTEN--THE KEY TO WHEAT'S UTILITY

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We are all aware that wheat gluten is important in wheat utilization. Although other factors must be considered, gluten is certainly the principal key to the utility of wheat.

Gluten, which is primarily the water-insoluble protein of flour, sets wheat apart from the other cereal grains. It confers properties to dough which make bread baking the present major outlet for wheat. Future expansion in the use of wheat industrially and in food will depend largely on taking advantage of the characteristics of gluten. I shall comment further on the contribution by wheat gluten to utilization and point out some of the recent progress at the Northern Laboratory in basic research on gluten that is moving us along toward the achievement of broader utility for wheat.

At the outset we should review what gluten is and where it fits into the picture of wheat as a raw material. Flour prepared by milling wheat is the usual source of gluten. The two main components of wheat flour are starch--around 70 percent dry weight--and protein--up to about 18 percent. In this respect, wheat flour is essentially the same as flour from other cereal grains; however, wheat flour can be made into an elastic cohesive dough by mixing with water. To separate gluten and starch from such a dough, it is washed with kneading in a stream of water. The kneading and washing carry the starch away and leave the gluten as a cohesive mass. This same procedure with some modifications is used commercially.

A continuous process for producing starch and gluten from wheat flour was developed in past research at the Northern Laboratory. The method has been

called the batter process because the first step involves making a thick batter out of flour and water. The batter is then mixed with more water to give curds of gluten and a suspension of starch. This process, or modifications of it, is being used commercially.

Elasticity and cohesiveness are the properties, as we noted earlier, that distinguish wheat from the other cereal grains. We believe that these properties and the factors responsible for them represent one of the keys to the use of wheat.

The loaf of bread on the grocer's shelf or the slice of bread on our dinner plate depends on gluten. Its presence permits the dough to rise as a result of the trapping and expansion of bubbles of gas to give the light structure and texture we desire. Yet even in this established area of wheat utility, there are problems concerning wheat gluten. Varieties and samples of wheat differ in baking quality of their flours. This variation is over and beyond that of the percentage of protein or gluten in the flour. Obviously, there must be differences either in the gluten or in the influence of other components in the flour on the gluten. These differences give rise to inadequate mixing and baking properties for flour from some varieties of wheat. Thus for the baking industry, an understanding of gluten and its properties is essential to the most successful use of wheat.

How about the relationship of gluten to industrial uses of wheat? Some of the characteristics of gluten immediately suggest possible uses. For example, gluten has natural film-forming tendencies as exhibited in the filmy wall between bubbles in a dough and breadcrumb. Indeed clear pieces of film can be prepared from wheat gluten. However, film properties need to be improved if they are to provide a basis for wheat utilization. Gluten films become brittle and lack the resistance to water that is required for many types of applications.

Many other uses have been proposed for wheat gluten. One is in adhesives. Here again we find that quantitative tests show unmodified gluten does not come up to the standards required for industrial use. Indeed, we have reviewed the patent literature on gluten and found descriptions of many products and applications. Yet we know that, in general, these patents are not being practiced. A logical conclusion is that, despite the claims, the quality of these gluten products is not good enough in itself or at least in relation to the cost of gluten. Yet we are confident that advantage can and will be taken of the unusual properties of wheat gluten as a foundation for increased industrial utilization of wheat.

When we ask what can be done to change and improve the properties of wheat gluten the answer is most likely to come through research. Progress being made will be the subject of the remainder of this discussion. We shall see something of what the cereal chemist is finding out about wheat gluten and why it has its elastic and cohesive properties.

Of what does wheat gluten consist? Some 80 percent or more of the solids in a mass of gluten is protein. In addition, lipids, starch, and various minor components are present. While gluten is primarily protein, its properties are influenced by some of these other components, such as lipids, as will be discussed by Dr. Pence. However, I shall consider only the protein portion of this gluten complex.

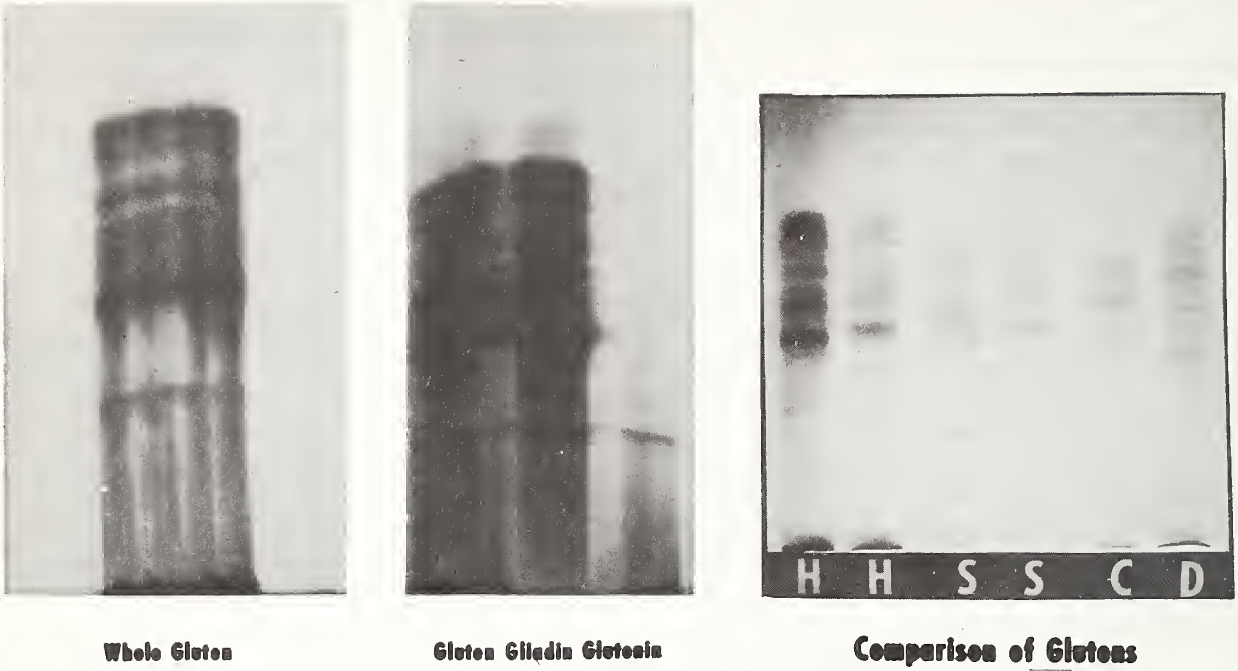
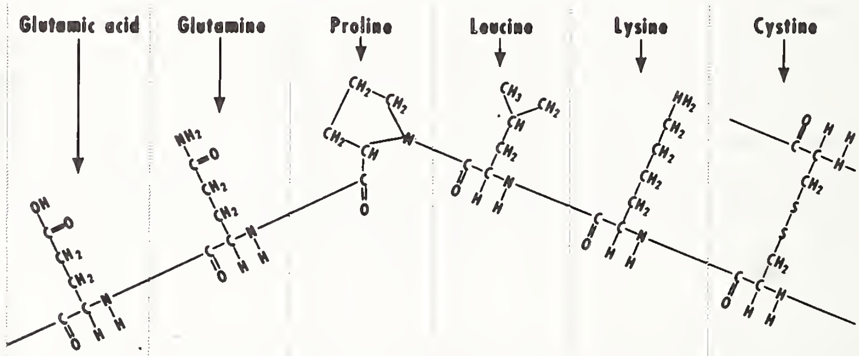


Figure 1. Electrophoreses patterns. The letters HHSSCD indicate hard, soft, club and Durum wheats.



Type	Acidic	Amide	Secondary	Neutral	Basic	Sulfur
Content	?-Low	42%	14%	7%	1.2%	2.1%
Significance	Negative charges	Hydrogen bonding	Twists peptide chains	Nonpolar	Positive charge	Cross-linkage

Figure 2. Representative amino acids in wheat gluten protein.

When the study of a protein material is undertaken, one of the first questions is whether it is made up of only one protein or several. A satisfactory answer has become possible only during the past few years. For a long time it was thought that there might be only two in wheat gluten. This belief was based on work done over 50 years ago by a pioneer in cereal chemistry, T. B. Osborne. He showed that gluten could be separated into two fractions, on the basis of solubility in aqueous alcohol. The more soluble fraction was named gliadin while the insoluble fraction was named glutenin.

The two fractions, when hydrated, are quite different in properties. Glutenin is rather similar to the original gluten, although tougher and more rubbery so that it does not stretch as easily. The wet gliadin is sirupy and flows readily from the stirring rod. The properties of these two fractions appear to be blended in the original gluten, which not only is cohesive and elastic but also is to some degree soft and fluid. This combination of properties is important in bread dough.

Returning to our question of how many proteins there are in gluten, we see that there must be at least two. A more complete answer has only recently become possible as a result of new methods for the study of proteins. These have been developed by chemists working in other fields, such as the proteins of blood plasma. Cereal chemists have had to do considerable research to apply these new tools to wheat gluten proteins.

A particularly important technique has been starch-gel electrophoresis. The apparatus includes two plastic trays into which cooked starch is poured and allowed to solidify. A small piece of filter paper is then soaked in a solution of the protein and placed in a slit made across the starch gel near the center of the tray. At each end of the tray of starch gel is a piece of heavy filter paper that is wet with a salt or buffer solution and connects the gel to a source of electric current. When an electric current (d.c.) is passed through the gel, it makes the protein move. The rate at which each protein moves depends on the number of particular kinds of chemical groups in the protein. Therefore, different proteins generally will move at different rates and be separated in the starch gel. After the electric current is turned off, the proteins are located by applying a dye to the gel. The individual proteins then show up as colored bands.

Of course it is possible for two or more proteins to be in one band if they have the same relative amounts of particular chemical groups. For wheat gluten starch-gel electrophoresis shows about eight fairly distinct bands and several others that are very faint and not always visible. In addition, there is a heavy band at the bottom of the pattern. This is the starting point at which the paper containing the protein solution was inserted into the gel. The protein in this band moves very little if at all (see Fig. 1).

Now, what does starch-gel electrophoresis show about the distribution of components between gliadin and glutenin? Patterns for gluten and for the gliadin and glutenin fractions show that, for all practical purposes, all the protein of the gliadin moves into the gel, whereas none of the glutenin protein moves. The occasional faint band of moving protein in the glutenin pattern undoubtedly results from a little gliadin protein remaining in the preparation.

Failure of the glutenin protein to move into the gel during starch-gel electrophoresis can be explained on the basis of molecular weight measurements we have made. The glutenin molecules are much larger than those in gliadin. The glutenin molecules simply are too large to move through the extremely small pores of the starch gel (see Fig. 1, middle section).

Starch-gel electrophoresis opens the way to a more detailed study of the proteins in wheat gluten. One area to be investigated is the gel patterns for glutens from different varieties of wheat. Although patterns from hard, soft, club, and Durham wheats are very similar, there are differences. Some of the patterns have more bands than others and in some cases corresponding bands in one are darker than in another. Considerably more research needs to be done before we can say whether any of the differences are related to differences, for example, in baking quality of wheats (see Fig. 1, at right). The important point, however, is that starch-gel electrophoresis gives us one more tool with which we can gain more knowledge.

Another important piece of research equipment we are using is the amino acid analyzer. As you know, amino acids are the building blocks that make up the protein molecules. Since the relative amounts and kinds of amino acids in a protein influence its properties, quantitative measurement of the amino acids is an important step in characterizing a protein. The complexity of this job becomes apparent when you consider that wheat gluten proteins contain 18 different amino acids. The Rockefeller Institute has developed automatic equipment for making quantitative measurements on other proteins. With this analyzer the amounts of each of the 18 amino acids in a wheat gluten protein fraction can be measured in about 24 hours with greater accuracy than was possible by the earlier manual method, which required nearly a week for the same determination.

Some of the amino acids in wheat gluten and their importance are given in Figure 2. One of each of the main classes is linked together chemically as it is in the protein. I shall not go into the details of the chemistry of these classes but shall only take time to point out certain important features.

The first two amino acids in Figure 2, glutamic acid and glutamine, are alike except for the group at the top. Glutamic acid has an OH on the C=O which makes it acidic. What little glutamic acid is present in the gluten protein influences the movement of the protein in gel electrophoresis because of the negative charges contributed by this group. The next amino acid has an NH_2 group at the end, which makes it an amide. About 42 percent of the wheat gluten protein is glutamine. The amide group supplies forces which help to hold molecules of proteins together. Our studies of chemical modification of gluten have shown that replacement of the amide with a less effective group, such as an ester, completely destroys the cohesive elastic properties of gluten. Because of the abundance of glutamine in gluten and its obvious contribution to properties, chemical changes in glutamine have become an important part of our exploratory research on the chemical modification of gluten proteins in order to change and improve their properties.

The next amino acid, proline, puts a kink in the chain of amino acids, as is indicated diagrammatically in Figure 2. Since proline accounts for some 14 percent of the total amino acids, its kinking of the chain undoubtedly makes

an important contribution to the properties of wheat gluten. Leucine, the fourth amino acid, is one of several neutral amino acids in wheat gluten. They have hydrocarbon side chains and contribute to the insolubility of proteins in water. Lysine, the fifth amino acid, is probably familiar to you as one of the nutritionally essential amino acids. Wheat gluten protein is relatively deficient in lysine, having only about 1.2 percent. Lysine contributes to the movement of the protein in starch-gel electrophoresis because of the positive charge which it imparts.

Last but not least is cystine, a sulfur-containing amino acid. The upper end of this unit is part of a chain of amino acids just as the lower end is. Therefore, an important function of cystine is to provide a crosslinkage of two chains of amino acids through the two sulfur atoms, referred to as a disulfide linkage. The importance of the disulfide linkage to wheat gluten properties has been known for many years. Splitting of this linkage by adding a reducing agent to a dough will immediately destroy its elastic properties.

Recently we have obtained a more complete picture of what happens when the disulfide linkage of cystine is broken. To do this, we used starch-gel electrophoresis and also molecular-weight determinations. The alcohol-insoluble or glutenin fraction of gluten contributes the elastic cohesive properties to gluten and, as might be expected, undergoes a profound change when the disulfide bonds are broken. As you will recall, glutenin fails to move into the starch gel. However, after the disulfide bonds are broken by reduction, essentially all the protein moves into the gel. Measurements of molecular weight confirm that this movement results from breaking the glutenin molecule into smaller fragments. The original glutenin had molecules of many different sizes with molecular weights ranging up into the millions. The fragments obtained on reduction were, unexpectedly, all about the same size, down around 20,000. Proteins of this size move readily through the gel on electrophoresis.

The presence of a number of bands in the pattern for reduced glutenin is a most interesting observation. These bands show us that a number of different kinds of proteins or chains of amino acids are linked together by the disulfide linkages in the glutenin. This discovery opens up a whole new area of research. One question we are trying to answer is what relationship there might be between these components of the reduced glutenin and the individual proteins that appear in the electrophoresis pattern of gliadin. The presence of a number of proteins in reduced glutenin also raises the question of whether differences can be found between different varieties of wheat in terms of the number and amounts of components produced by reduction of the glutenin. Finally, breakage of the disulfide bonds might be another important step toward the production of industrially useful products from wheat gluten since the fragments formed are of relatively uniform molecular size. We can be sure that research, seeking answers to these and related questions, will be of direct value to the utilization of wheat.

The use of chemical reactions to change the properties of the wheat gluten proteins has been mentioned several times. Our research in this area is concerned, in part, with reactions of gluten proteins themselves and, in part, with simpler model compounds. The model compounds are synthetic polymers of individual amino acids instead of the 18 different amino acids in gluten. Some of the progress we are making is shown in the tabulation below. I must emphasize

at the outset that these are only preliminary research results. Much evaluation and development have to be done before any of these results can lead to practical applications. The list brings out, however, some of the products we are seeking and the progress being made.

Gluten modification research achievements

New chemical derivatives:	
Deamidated gluten	soluble in water
Methylated gluten	soluble in alcohol
Benzylated gluten	soluble in chloroform
New crosslinking agents:	
Tolylene di-isocyanate	stronger, more water resistant
N-Acetylhomocysteine thiolactone	more disulfide bonds
New solvents for reactions:	
Benzyl alcohol-acetic acid	benzylation
Dimethyl sulfoxide-acetic acid	deamination
Superior films from amine acid polymers:	
Polybenzylglutamate films	strong, water resistant

The chemical derivatives in the first group all involve chemical transformations of the amide group in glutamine. Profound changes in the solubility of wheat gluten result from the different types of chemical modification applied Removal of the amide groups gives solubility in water; transformation of amides to methyl esters gives solubility in alcohol; and transformation to benzyl esters gives solubility in chloroform. The second group is concerned with increasing the amount of crosslinking beyond that already present in gluten. The new crosslinking agents may give either a product more resistant to water and chemicals or simply a more highly crosslinked material. The search for new solvents for wheat gluten is important for getting better conditions under which to carry out reactions. The two solvent combinations listed in the tabulation above have proved particularly useful in chemical modification of the amide group, such as conversion to benzyl ester groups or to acid groups.

The last item listed above illustrates the use of synthetic polypeptides for studying the relationship between chemical structure and properties. Since glutamine is by far the most abundant amino acid in wheat gluten, we have given particular attention to polyglutamine and its modifications. When the amide group of polyglutamine is converted to a benzyl ester group, the resulting polybenzylglutamate gives films that are very strong and water resistant. We expect that such studies as these eventually will lead to industrially useful products from wheat gluten and from wheat flour containing gluten proteins.

Referring to our first statements on wheat gluten, we realize that progress is being made toward understanding and utilizing its unusual properties. We have seen that these are important in bread baking and that in some manner they must provide a basis for the use of gluten and flour industrially. We have seen that new tools and techniques have been brought to bear in the study of wheat gluten proteins. Through their use we are rapidly obtaining basic information on the complexity of the protein makeup of wheat gluten and about the effect of chemical modifications on its properties.

Wheat gluten is indeed a key to the utility of wheat, but having a key is not enough. We have to fit that key to turn in the lock and then push the door open. That door is big and heavy. We know that it is going to take the combined efforts of many research workers over a considerable period of time to expand wheat utilization. Yet we are confident from the progress already made that the portals will open wide.

THE IMPORTANCE OF BREAD FLAVOR

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Most of us judge our food's flavor, commenting as does the amateur art critic: "I don't understand art, but I know what I like." Our flavor preferences are individual. They are influenced by our prejudices, our experience, and our intellect. Flavor preference reflects both the physiology of our nervous system and the psychological framework that creates all our background thought. Flavor preferences are responses to a chemistry and electricity of our nervous system, stimulated by the food we eat and the aromas that surround us. The manner of the response is not even remotely understood and has been subjected to but meager investigation because no one has developed a suitable approach to experimental methods. Before we consider the importance of bread flavor, it is necessary to consider what flavor is and what factors influence flavor preferences.

Flavor responses are subjective, and if we would measure flavor we may do so by recording individual and group responses to substances and products. The trained expert, the test panel, and the statistical survey are three widely used approaches to this aspect of flavor research. Information is also obtained by the careful sniffing of tubes and flasks by individual scientists--who know what they like.

A widely prevalent sentiment expresses the idea that bread flavor today is not as good as it once was. I don't think the evidence for this is adequate. It may be only a highly vocal minority report. It may be another sign of middle age, like: "Newspaper print is getting smaller. The stairways are built higher. They seem to be letting young children enter college these days." Actually, tastes do change with age. Children prefer sweeter and blander foods; adults, the stronger flavors. Taste perceptions become jaded as we mature.

There are regional preferences of flavor (and other bread qualities, also) and the bread type still carries status significance. White bread was for centuries almost a symbol of the upper classes. Manor house records from medieval England accounted for crop yields of white wheat for the gentry, maslin for the household staff, and rye and peas for the villeins. (Maslin is a mixture of wheat and rye.) The nutritional gospel about whole wheat vs. low-extraction flour has prejudiced many in favor of dark-colored breads regardless of vitamin content or flavor.

Public preference for bread type and flavor today is influenced by a generation or more of exposure to the soft, high-volume, bland bread that is characteristic of the modern commercial-bakery white loaf. All of us have lived most of our lives in the era of commercial baking and our preferences have been influenced by the type of bread which has been readily available. Sales figures show a very large proportion of this type of bread is selected by the U. S. population.

I may not understand the refinements of making this type of bread, but _I_ like it. Of course, we attribute this popularity to textural quality and the relative resistance of this bread to staling, as well as its flavor. Because preferences do vary, the baking industry has responded with the various types and flavors and shapes and colors of loaves wanted in each market.

Flavor preference, then, is subjective and influenced by these individual prejudices. However, as its foundation the nervous system reacts to a chemistry of stimulation that is not subject normally to any change. One man enjoys Limburger, another is revolted by it. But, almost certainly, both undergo the same fundamental chemistry of sensual stimulation. Because we accept this as a basic fact, we direct our preliminary research attack on the bread flavor problem along lines of physical and organic chemistry. In this area, the experimental method _exists_, and is becoming more refined almost day by day. The other factors that are involved in and complicate the study of bread flavor--the experiences, prejudices, and so forth--may never be ignored.

To get a little closer to the subject of this presentation--the importance of bread flavor--one must consider economic implications. Bread flavor is important mainly if it affects the amount of bread sold or the cost of bread. Statistics are available on bread consumption that may be involved with the importance of flavor.

The decreasing per capita consumption of bread is an important fact of our society. A comparison of census figures in 1954 and 1958 reveals an 8 percent reduction in bread manufactured while the population was increasing about 5 percent. On the other hand, rolls and specialty breads increased more than 10 percent and sweet goods about 4 percent during those years. These increases nearly balanced the reduction in regular bread produced, but per capita consumption of bakery products dropped over the 4-year period. The Department of Agriculture has projected a 3.5 percent decrease in per capita consumption of wheat each ten years in the future (Daly, in _Agr_. _Econ_. _Res_. 8:84). The consumption of wheat by 1972 will be about 10 million bushels less per year if the trend continues, than it would be if per capita consumption were to hold its current level.

The lost markets in a decreasing per capita consumption trend reflect a number of factors. In the first place, the replacement of manpower by machines has reduced human energy requirements. A vast array of new food products competes with bread three meals a day. Living standards have improved and people are buying more expensive foods. Social stigmas and status seeking influence food habits. Diet fads scare people away from bread.

We cannot attribute directly the consumption loss to flavor. However, poor quality can certainly be a factor in bread acceptability. The achievement of better flavor may provide strength to resist the effect of other factors and arrest or reverse the trend in bread consumption. If it can accomplish this, bread flavor is a highly important factor to the entire wheat industry.

It is easy to demonstrate that fresh bread is definitely preferred over a stale or semi-stale product. Furthermore, a very great proportion of white bread available to customers is at least semi-stale before being purchased and not improved by the time it is eaten. This is becoming an increasingly severe problem with the urbanization of our population and the attendant difficulties in rapid distribution of products from bakeries to stores.

The effects of staling are hard to evaluate because both texture and flavor changes are involved. While many housewives select their bread purchases by the "squeeze" test, Dr. Bradley, Research Director of the American Institute of Baking, has stated the opinion that people don't object to firmness in bread, per se, if the flavor is reasonably good. If this be true, solution of the flavor instability of bread would alleviate the staling problem in a material way.

Not only is evaluation of flavor complicated with evaluation of texture, flavor is influenced by texture of bread. Thus a dense, compact crumb will give a stronger taste sensation than a very soft, finely divided crumb. Continuous-mix bread tends to give an impression of blandness, and for flavor equivalent to that of batch fermented and proofed bread, these tender loaves may require a more intense or highly concentrated chemical flavor source.

Another example of the texture-flavor phenomenon is found in the taste sensation of ice cream in relation to the degree of over-run. A brick of ice cream with lots of air in it does not produce the degree of cold sensation and is quite bland in flavor. Yet, the same formula frozen slowly with little air incorporated gives a very cold, icy sensation and tastes much sweeter and more flavorful than the aerated product.

Coarse-textured bread will seem firm and harsh much sooner than fine-textured bread. Because the U. S. preference for high-volume loaves seems incontestable, a higher absolute flavor level than would be required for coarse bread seems imperative. This demand is added to the problem of flavor loss through staling, which is of utmost importance.

We are told by economists that the demand for bread is inelastic. In their language this is no doubt true, and it has been subjected to statistical surveys of a definitive nature. The economist means that no more bread will be consumed if the price is reduced; no less, if the price is advanced. Of course,

if one grocer reduces bread prices for a Saturday sale, he'll undoubtedly sell more. The economist says that this will not increase the total consumption of bread in the community. However, I submit that a "non-price elasticity" exists that is based on quality. I think it may be assumed that good flavored, fresh bread will be consumed in greater quantity than poor flavored bread. I believe we can make that assumption and use it as the basis for research to improve markets for wheat and its products.

Bread flavor must be understood in detail before we can exercise a high degree of improvement. I indicated earlier that chemistry is a basic approach to understanding bread flavor. Three focal points for flavor chemistry research are: (1) What is the nature of bread flavor? (2) How does its nature change during staling? and (3) How can those changes be prevented?

Bread flavor originates with ingredients used and the changes that occur in the mixing, fermentation, and baking. Some of the ingredients are not flavorful in themselves, but are altered in breadmaking to be capable of stimulating our taste and odor nerves. Other ingredients are flavorful and also participate in changes bringing about the final bread flavor.

Mixing the ingredients causes little change. Sugar remains sweet; salt, salty; flour, bland; and the special ingredients, such as caraway seeds, honey, and so forth for specialty breads have their specific effects. During fermentation and baking, the ingredients are altered. When the yeast acts, important changes occur. Many volatile acids, alcohols, esters, and carbonyls are formed by the yeast enzyme systems. Many of the new compounds have strong and distinctive flavors. While the bread bakes, some of the compounds disappear in the oven exhaust. Some are changed to new flavors; and, a new, heat-induced set of compounds add important flavor notes. Finally, as the bread waits to be eaten, staling causes further changes in flavor.

Chemists here and abroad have catalogued various chemicals that may be detected from fermented dough, baked bread, and oven vapors. In the course of research, many important, powerful, and sensitive methods have been developed to study bread flavor chemistry. The tools of research for separation and identification of chemical compounds are being improved almost on a day-to-day basis. Just as the equipment of industry has been refined and automated so has the apparatus of science. We now have equipment that can separate and identify many chemicals at the extremely dilute concentration that naturally occurs in oven vapors and bread aromas. For some compounds this sensitivity is even below the concentration that can be detected by smell. This is not to say that the instrument is as sensitive as the nose. There remain other chemicals that are so odorous that they can be detected in even more dilute occurrence. For these we need still more advanced equipment.

Just a year ago Dr. Wiseblatt of the American Institute of Baking published a comprehensive review on "Bread Flavor Research" (Bakers Digest, 35(5), 60-63, 174, 176, October 1961). He listed many aromatic substances that had been isolated and identified from preferments, doughs, bread, and oven vapors by various investigators who have published their research findings. In as brief a presentation as this, there is no point in repeating the names of compounds found thus far. They are well known by the specialists and are not in themselves of general interest.

It may be sufficient here to indicate that such investigations are continuing in several laboratories in this country and also abroad, to identify such compounds. Scientists are looking with more and more skill for the ingredients and the combinations that will adequately describe the nature of bread flavor.

At each stage of the breadmaking process, chemical components are identified and their relationships to flavor sought. Ingredients, including separated chemicals known to be related to flavor, are added in different proportions to preferments and doughs to learn how bread flavor can be altered. Processes are modified to learn how various operations in breadmaking can alter the flavor.

Bread staling is also subjected to investigation. The aroma of bread and extracts of bread are studied to learn what chemical compounds are found and what changes are detected as bread is held for several days. Some of the compounds obtained from preferments and from oven vapors have been altered chemically to resemble the odor of stale bread. These are important clues in the continuing search.

I want to close with two points. First, there have been many significant advances in recent years in the chemistry of bread flavor, and the tools of research have advanced so that future progress should be at an accelerated pace. Second, there is still a long way to go before the chemistry of bread flavor is so well understood that we can adjust the ingredients and processes of breadmaking to obtain products of superior flavor that are resistant to staling. We are certain that the answers are attainable and, we also believe that when such superior bread is available, more bread will be eaten.

CHEMICAL FOUNDATIONS FOR WHEAT QUALITY CHARACTERISTICS

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Of all the growers, millers, and bakers in this audience I wonder how many consider themselves as being in the chemical business? In a strict sense it can be said that a wheat grower is a chemical producer; a miller is a chemical processor or refiner; and a baker is a chemical manufacturer. This is a strange way of thinking because we usually classify agricultural chemicals as fertilizers, weed killers, insecticides, and so on. When our attention is focused on the point, we all recognize however that all food materials, all machinery, all people--in fact, everything about us is chemical in nature. The wheat kernel is a package of chemicals put up in a chemical wrapper. The chemicals in this case, however, are rather complex as Dr. Dimler showed and as we shall see further.

I shall confine my remarks to just a portion of the wheat kernel--the inside--the contents of the package. This material comprises about 85 percent of the kernel and is the portion we call flour. It is a marvelous mixture of complex substances whose composition and properties we only partially understand. I'll review some of the principal attributes of these chemicals, why they are so important to all of us, and some of the recent knowledge we have gained about them. Dr. Dimler has given us a lucid discussion of proteins. I will include proteins but will talk also about carbohydrates and fatty materials in flour.

Proteins, fatty substances, and carbohydrates are not the only chemicals in wheat flour, but they are major and adequate for a short discussion. As you know, the protein of wheat can vary from as low as 5 or 6 to as high as 18 percent, or even higher. Around here a range of 11 to 14 percent is more realistic. Flour from such wheat will have a protein content of 10 to 12.5 percent. Starch and other carbohydrates will account for roughly 85 percent of the flour, and fatty substances from 1.5 to 2.5 percent. Despite the differences in quantity, all of these constituents are very important in the functioning of wheat flour, and I'll try to explain why. If a choice has to be made as to which is most important, we would say the proteins, because the gluten proteins distinguish wheat from all other cereals. There are differences among cereal starches and fatty substances, but none quite so profound in effect as the difference in proteins.

Let's first consider starch because it is present in greatest quantity. It is far more important than is generally recognized. It is essential for the production of baked products and other wheat foods as we know them, and I am convinced that a significant part of the variations in performance among wheat flours is due to unrecognized differences in the starch and other carbohydrate constituents. No one has done more to demonstrate the importance of starch in baked products than Professor R. M. Sandstedt here on the Nebraska campus. Much of our knowledge about the importance and behavior of wheat starch has emerged from his classical work.

Figure 1 was originally prepared by Dr. Majel Macmasters' group some time ago before she came to Kansas State from the Peoria Laboratory. It shows part of a cross section of a wheat kernel. The top third shows the various bran layers and the prominent aleurone layer just below, but I want to call your attention to the kernel cells in the lower half. Here you can see how the cells are packed chock-full of globular objects of different sizes having a little dark patch on them. These are starch granules--some big and some quite small. Much of the protein in the cells occurs between the starch granules--in the little odd-shaped spaces where the rounded starch granules do not touch. In addition some of the protein is smeared across the surfaces of the starch granules in thin layers. Much of the fatty material in flour is associated with the protein material.

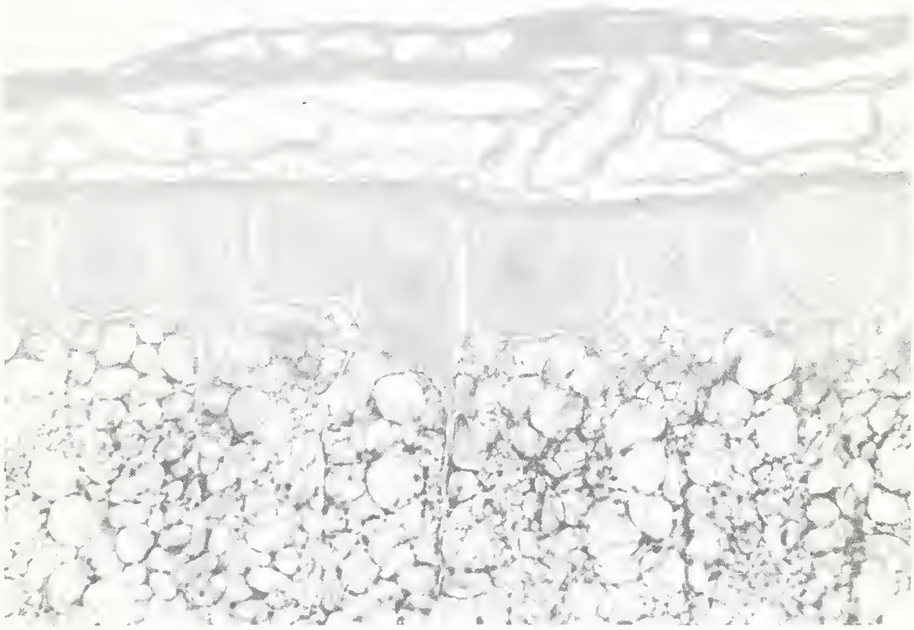


Figure 1. Cross section of a wheat kernel.

When water is added to wheat flour, and mixing is commenced, the protein material becomes quite sticky. It tends to stick to itself a little more than to other materials, so that it pulls away from the starch granules, leaving them at least partially bare. When an excess of water is added to a dough and gluten is washed out, a great many of the granules are essentially bare. In doughs, however, starch granules probably are immersed at all times in a proteinaceous film. Unless they have been broken open or damaged in some manner during flour milling, the starch granules to a great extent are inert during dough mixing and fermentation. They don't hold much water, don't contribute much to fermentation, and so on, but they do provide a structural rigidity to the dough mass--somewhat like the sand and gravel aggregate in wet concrete. During baking, however, the starch granules swell up and grab whatever water they can from any other ingredient and form the primary supporting structure of a loaf of bread, for example. How well a particular flour fulfills its quality functions depends in no little degree on the nature of its starch and other similar carbohydrate constituents.

Let's take a closer look at how a starch granule is thought to be constructed to see how variations in behavior might arise. First of all starch and other large carbohydrates are formed from small structural units called simple sugars. If the sugar contains six carbon atoms it is called a hexose; if five carbons, it is a pentose. When two or more are linked together, it is necessary to remove a molecule of water from between them. Thus large molecules made up from pentose sugars are pentose anhydrides or, more commonly, they are called pentosans. Similarly hexose anhydrides are called hexosans. Since starch is made up of the common simple sugar called glucose, it is a glucosan.

The glucose units in starch are largely but not completely hooked together end-to-end in long strands. Sometimes these strands become branched, however, and the extent of branching, the length of the branches, and the ratio of branched to unbranched forms all have important effects on the properties of the starch and in turn on baking quality. A starch granule might be organized as shown in Figure 2. This is a highly idealized concept. This structure was originally prepared back in 1895 and has some faults, but it will serve our purpose. Note the generally outward orientation of the chains and how the branches tend to interlock and line up side by side to form the overall structure.

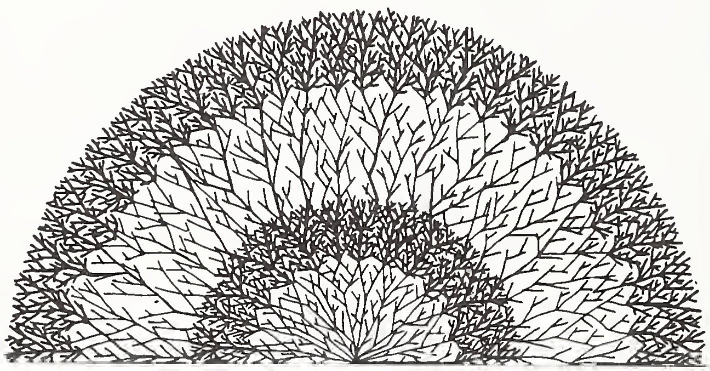


Figure 2. Construction of a starch granule.

The left-hand portion of Figure 3 shows an enlarged segment of the sort of structure shown in Figure 2. Here, the side-by-side alignment of the chains and branches is plainer. The right-hand part of the slide shows how the condensed structure can be forced apart by the intrusion of water molecules when the system is heated or otherwise triggered. In this extended form the starch molecules are now readily susceptible to enzyme attack, which will chop up the chains into the original small sugar units or small multiples thereof. When this happens, the water-holding capacity of a dough or gel drops tremendously. This is why enzymes in flours and doughs must be kept at a suitable level and why starch-granule damage during milling must be kept within limits. Both miller and baker are very careful to check these properties in their products.

Other large carbohydrates such as pentosans and hexosans, besides starch, are also present in wheat flour and have effects on quality characteristics that are even less understood than those of starch. Research is under way on these substances in several places, but there isn't time to review it this morning. Suffice it to say that the carbohydrates are of decided importance to

bread flour properties and of great importance in cookie and cake flours. Not nearly enough is known about them to permit rational testing in advance of baking, except for tests which indicate the degree of starch granule damage during milling or for water absorption under alkaline conditions. The latter test is valuable for cookie flours and reflects the content of pentosan and other poorly characterized carbohydrate substances of large size.

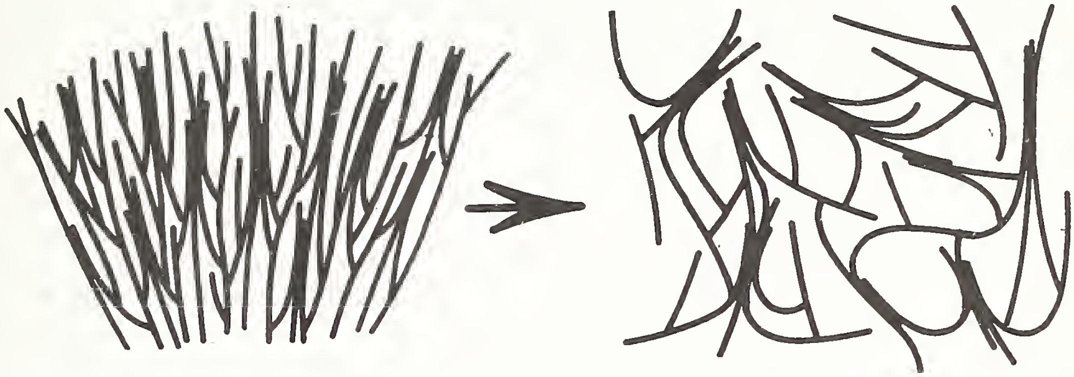


Figure 3. Unswollen (left) and swollen (right) segments of a starch granule.

Let's now consider the next most abundant constituent in wheat flour, the proteins. Dr. Dimler has given you an excellent outline of the intricacies of the gluten proteins. Other proteins are present, however, and have been shown to influence the baking performance of isolated crude glutens enough so that they must be considered as important constituents from the quality standpoint. That much is easy to say. To go on to explain how and why is a much different matter.

The so-called soluble proteins in flour, albumins and globulins, may comprise up to 20 percent of the total protein, with gluten making up the rest. By themselves the soluble proteins have none of the elastic and plastic properties of gluten. They can, however, modify these properties of gluten, and herein may lie their importance. Certainly they become intermingled in some manner or other in the gluten ball when gluten is washed from doughs. The magnitude of the task of finding meaningful relationships among wheat proteins is exemplified somewhat by the fact that to date some 25 to 30 individual proteins have been found in wheat flours.

When considering relationships between proteins and quality, one first thinks of the total quantity of protein. This time-worn but never quite adequate relationship is familiar to all, as are its shortcomings. So one then thinks in terms of quantities of the different types of protein in flour and the proportions of each. In former years much largely fruitless effort was expended in trying to relate crude gluten contents of flour to baking quality. This also proved to be too loose a relationship to be as reliable as desired. Not until recent years was it known that determination of the true gluten content of flour is a complex and difficult task. The gluten washing test is still widely used in Europe, however, and is useful under circumstances there. It is seldom used in this country any more, because it simply does not give enough precise information for our purposes.

A significant relationship of the albumin-globulin ratio to baking performance was found in our Laboratory a few years ago, but the test in its present form is too time-consuming and imprecise to be useful for purposes other than research. Efforts are continuing. Methods are being worked out to determine the quantity of each type of protein, as well as the major components of each type, so that meaningful relationships can be found to serve as the basis of improved tests for quality. This work is being done for us under contract arrangements, and some impressive advances have been made. However, successful as such efforts may be, it is unlikely that this approach will be sufficient. Therefore, we are also working in other directions.

Probably most of you have heard people refer to mixing time and mixing tolerance as critical quality criteria of flours. The mechanical development of a bread dough actually is a key to its utility. The work performed on the mere paste of flour and water somehow transforms it into a smooth, strong dough having both elasticity and ability to flow. A good dough must be elastic enough to retain its gas bubbles, but at the same time it must yield to the pressure of these gas bubbles and expand to a good final loaf volume. From whence do these essential properties arise?

The answer, at least in large part, lies with the proteins and fatty substances. The elasticity needed probably comes from the proteins and the flow is probably aided by the fatty materials naturally present. Let's take a look at some of the chemical properties of proteins to see how all this may come about.

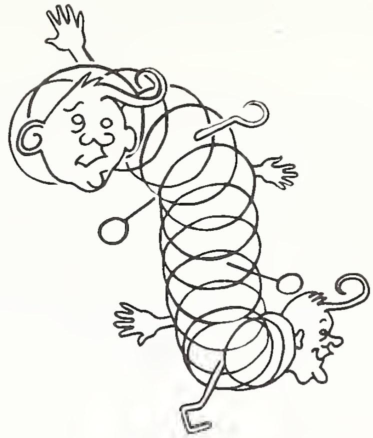
Proteins are very large molecules formed from the 18 amino acids Dr. Dimler mentioned, all hooked together to make very long chains, somewhat similar to those of the large carbohydrate molecules. The proteins, however, being made up of so many different building blocks instead of just one or two or three, can differ enormously in their specific chemical properties. The long chains normally are kinked and coiled, often in a spiral shape like a spring. These kinked and coiled chains can be extended elastically. Moreover, they can form into long coiled bundles or ropes that also can have elasticity. The backbone chains of the individual proteins and the bundles and ropes of several protein chains are held in these coiled shapes by a very large number of hydrogen bonds that Dr. Dimler described. Each hydrogen bond is very weak, but when enormous numbers are acting, the total effect is great. Another type of bond that holds protein chains in a configuration is much stronger and is called a disulfide bond. Dr. Senti and Dr. Dimler discussed this type of bond in their talks. Let's go to some graphic illustrations again to see how these bonds exert another of their important effects.

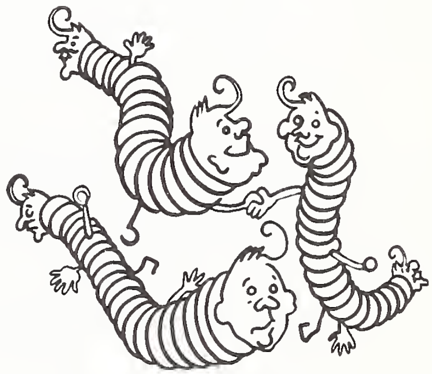
Figures 4 to 7 show a fanciful conception of protein molecules and their behavior. Each is nothing more than a simple coil spring with here and there on its outer surface some odd-shaped projections. These represent in a crude way some of the reactive groupings that project from the surface of protein molecules. The hooks and eyes can link up with counterparts on other large or small molecules; or different molecules can stick together by means of the many hydrogen bonds, not shown, which make the surfaces sticky towards one another. I want particularly to call your attention to the projections on this spring that look like human hands. This is a way of depicting a sulfhydryl group.

Figure 4 (right). Schematic representation of a protein molecule showing sulfhydryl group as an open hand.

Figure 5 (below). Clasped hands represent a disulfide bond between molecules.

Figure 6 (below right). Interchange mechanism of sulfhydryl-disulfide linkage.





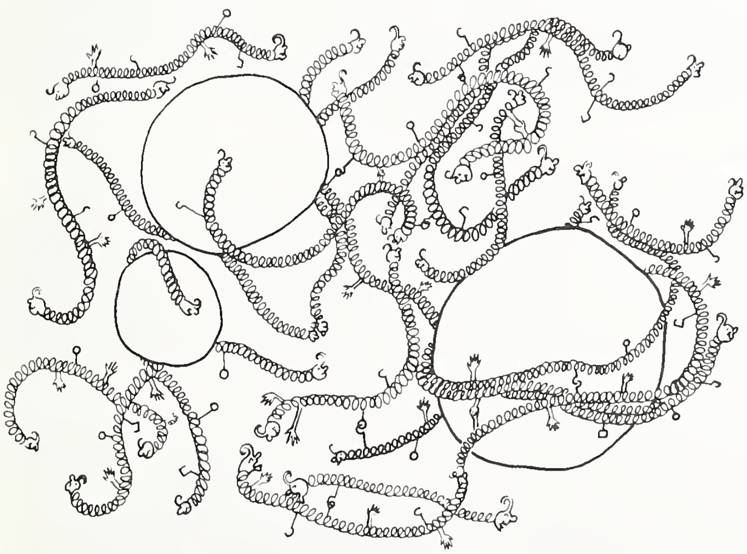


Figure 7 (left). Suggestion of complexity of inter-molecular association of protein molecules in doughs and gluten.

When two hands come close enough to clasp each other, we can say that they have formed a disulfide bond holding protein chains together rather firmly and rigidly.

Now, these disulfide bonds have a peculiarity that is important in doughs and to dough properties. They are very friendly bonds. When a third sulfhydryl group, or unclasped hand, comes along, the pair that was originally clasped will unclasp and one of the hands will shake with the new hand. The leftover hand, or sulfhydryl group, will now have to move along to find somebody else to shake with (Figs. 5 and 6). If this goes on very long, pretty soon we have a crazy mixed up mess, because each molecule may have several hands. This crazy mixed up mess (Fig. 7) is the sort of situation we have in a bread dough after mixing. In fact, in a dough it is much much worse because in addition to the tangle of protein chains there is a flock of starch granules around, as well as a lot of other molecules, including some vicious enzyme molecules which will bite a chunk out of the protein chains or opened-up starch molecules whenever they get a chance. Finally, the whole business is immersed in water which lubricates everything. One more thing should be mentioned, and that is oxygen. We might think of oxygen as a bowling ball which, if grabbed by one of the sulfhydryl hands, prevents the formation of a disulfide handclasp. However, the sulfhydryl hands would much prefer to be in a disulfide bond, and so they are quick to clasp each other, if possible, whenever an oxygen bowling ball comes along.

Now, let me caution you that this series of cartoons represents a greatly simplified, distorted, and exaggerated concept of the true situation. They should not by any means be taken literally. They do illustrate a few of the factors that must be considered in finding out what goes on in a dough or batter.

For some time now we have been studying the sulfhydryl groups in wheat flours and what happens to them during mixing. We have found that different types of flours (spring-wheat, winter wheat, club-wheat flour and so on) show characteristic differences in the way the sulfhydryl groups disappear during mixing. At the same time the solubility characteristics of the total protein, but particularly what appears to be the glutenin protein of gluten, change markedly and in a characteristic manner. It has not yet been possible to track down the individual components that are involved nor the numbers and locations of the sulfhydryl groups on individual protein components, but this information will come in due course.

In addition we have also engaged in separation studies on the soluble proteins to learn how many there are, what their principal properties are, and how they can be purified in sufficient quantity for special tests on them singly and in combinations. Such tests will be designed to throw light on how each kind of protein operates in a dough or batter. We need to know molecular sizes and shapes, the number and kind of reactive groups, like the sulfhydryl groups, and so on.

Progress is never as rapid as we would like, but we have shown that there are at least 17 albumin and at least 3 globulin components among the soluble proteins. Some of the albumins have been purified enough to justify amino acid analyses. Others are nearly at that point. The enzyme activity of some has been tracked down, and several other enzymes are in various stages of separation.

Some of the components can hook up with some of the large types of carbohydrates in flour, such as the pentosans and hexosans other than starch. These combinations are of interest in connection with the effect of oxidizing agents on doughs and in connection with cookie and cake baking qualities, as opposed to breadmaking quality. Effort is directed toward learning more about the chemical foundations of flour quality. As fragments of the picture become known, they will be reported in future meetings.

I've mentioned the fatty substances in flour and alluded to their importance in flour performance. The term lipids includes all types of these substances. The class that seems of greatest importance contains phosphorus in the molecule and is called phospholipids. Common fats are made up only of fatty acids and glycerine. Phospholipids also contain phosphoric acid and may contain some organic bases.

Phospholipids appear to have a peculiar affinity for the glutenin proteins of wheat flour. When a dough is formed they become attached to glutenin almost completely. Although the lipids represent only a very small part of flour, they are important because when they are removed, baking performance is drastically affected. One important apparent function of phospholipids is to provide a means for the flow of dough when it is stretched, mechanically or by gas bubbles.

When a dough is stretched, it tends to pull back to its original shape but never quite makes it. This means that some of the molecules have slipped past one another during the elongation period. If all of the protein molecules were hooked together with disulfide bonds or other strong bonds, the doughs would be much more elastic and would pull back completely when released after stretching. They would also be unsuitable for bread. A certain amount of slippage is essential, and phospholipids or related lipids appear to provide the mechanism.

The leading theory of the function of phospholipids indicates that the proteins of gluten in a mass, or in a dough, are collected in little flattened blobs or platelets. These are mostly surrounded by a layer of water, but also may be stuck to one another. Every once in a while one of the platelets will be attached to a double layer of phospholipids, and usually the other side of the phospholipid double layer will be attached to another protein platelet.

Figure 8 shows a few protein platelets and a double layer of phospholipids. The phospholipid molecule is somewhat elongated with head and tail. Because heads like other heads and tails like tails, they line up to form the double layer. It happens that heads also like proteins, and will attach themselves firmly to the protein platelets. Now, when the whole business is stretched, the tail-to-tail portion of the double layer slips to relieve a part of the tension that is applied. This causes the gluten or dough to flow a bit and be less effectively elastic. This is about the best theoretical model of the structure that can account for the observed experimental facts even reasonably well. There are objections to some features, but no one has yet come up with a better one.

So far as anyone has yet been able to determine, flours generally seem to contain an adequate amount of phospholipid and other fatty substance. This

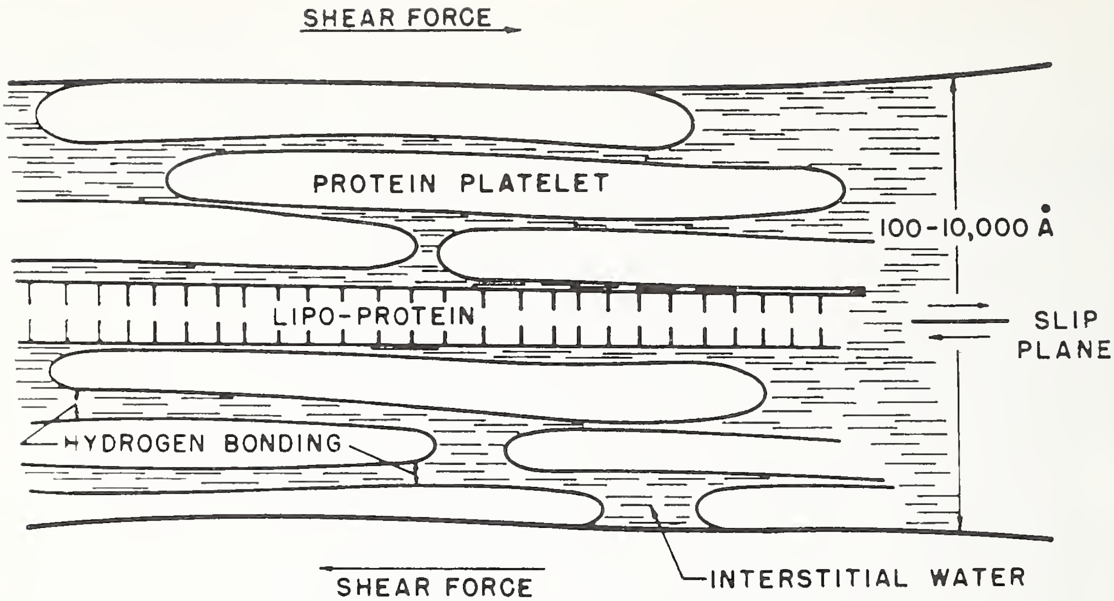


Figure 8. Hypothetical gluten sheet showing double layer of phospholipid in the lipoprotein slip plane (from Grosskreutz).

is not necessarily true, however, because flours differ in the amounts of types of fatty substances they contain. Until we know more about the various lipids and how they all participate in dough functions, we can't tell how much of the quality differences among flours are caused by the lipids. Thus, our Laboratory and others are studying flour lipids intensively. We have two active projects on this subject financed by Public Law 480 funds in England and France in addition to our work in Albany.

In a few minutes, I've tried to lay out some of the chemical foundations for wheat quality. Much of it has been theoretical and complex. You may rightly ask, What good is this high falutin stuff? The answer is that cereal chemists have gone about as far as they can with quality tests and evaluation on the old-fashioned cut-and-try, empirical basis. Total protein is a fairly good index of flour quality; so is the Zeleny test. Baking tests in the laboratory are even better. However by themselves, none is yet good enough as pointed out so forcefully by Steve Vesecky this morning.

All of the available tests so far have serious shortcomings. The same is true of baking tests. Far too often a baker gets a flour with analytical and test results very close to those of other flours. Yet, for some unknown reason the flour just won't bake properly. The repercussions go all the way back down the line. If such a thing happens to a baker overseas, he may very well be swayed away from U. S. wheats and toward those of other countries. Often merchandise with a little off-quality sways domestic consumers toward another baker's product. Or, worse yet, away from baked products to other foods.

As baking methods change and as flour specifications become more stringent, it becomes increasingly necessary that flour qualities be accurately measurable and predictable--that they can be clearly described and defined for

the miller and for the breeder--that flours can be produced and controlled to meet specific requirements. Such progress at this point can only come from knowing more about the raw product itself, as well as the many products derived from it. A detailed and comprehensive knowledge of the chemistry of wheat and flour is as vital to the wheat industries as is similar knowledge to the steel industry, the plastics industry, the petroleum industry and others. These industries are far ahead of us. We must hurry to catch up.

Discussion: The mechanism of coagulation of gluten by heat and water was described as a process whereby chemical linkages are changed in a manner that makes the protein insoluble. With partial coagulation, the ability of the gluten to flow is reduced.

MORE VERSATILE WHEAT FLOURS BY AIR CLASSIFICATION

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A wide variety of requirements are imposed upon wheat for today's uses in foods or for possible industrial products. Definite properties and compositions are required of flours depending upon the use to which they will be put. As specialization increases with the introduction of additional products and processes, the specific quality requirements and need for uniformity from lot to lot will also increase.

When milled by conventional methods, each wheat blend yields flours having a relatively narrow range of composition, but variations in weather and growing conditions from year to year can greatly change the quality and composition of available wheats and thus complicate flour quality control. Excess rain or drought, early or late frosts, and extremes in temperatures can cause protein variations in a variety amounting to as much as 5 percent. Fertilizer levels, geographical location of production, irrigation, and similar factors also can cause variations in the composition and properties of wheats.

The picture is further complicated because many users of flour have their own specifications that may require special properties or compositions; moreover, a bread flour considered adequate in one geographical area may be unacceptable in another. All these factors emphasize the enormity of the problem

of using available wheats of varying properties to mill the flours that can be most satisfactorily used by the purchaser, and of maintaining uniform flour characteristics from year to year or even from month to month in the same region.

Fortunately, during the past decade a new development gives a measure of relief from the vagaries of nature and permits us, within limits, to control flour composition and "tailor make" flour from the wheats available. This technique is the fractionation of flour by fine grinding and air classification. It is now used by a number of millers, and many others are giving it serious consideration. At the Northern Laboratory we have been conducting a rather detailed study of this process as a part of our studies to increase wheat use in foods and industrial products.

First, let us see how air classification works. Figure 1 represents the basic principle, which is comparable to the winnowing of wheat to remove chaff. Air classification consists essentially in the preferential deflection of the smaller, lighter particles when air is blown across a moving stream of flour particles or when an air stream carrying flour particles is forced around a corner. In each case the larger, heavier particles tend to continue in their original path while the smaller, lighter particles tend to follow the air stream.

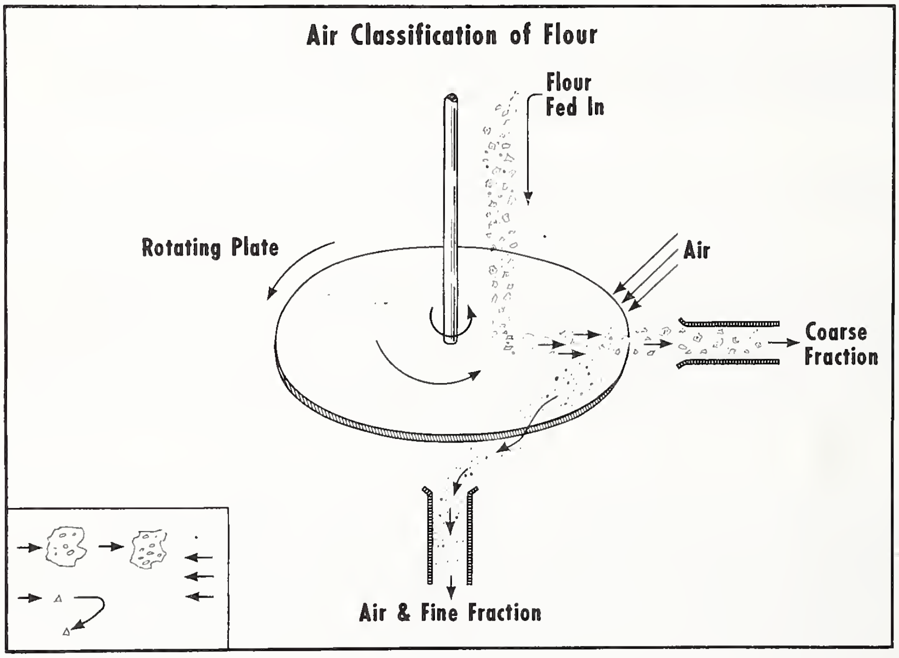

Figure 1. A schematic diagram of air classification.

In this diagram (Fig. 1) a stream of flour falls on a spinning disc and is brought up to full speed on the disc. As the flour is thrown off the disc toward an outlet, a stream of air is directed at an angle to the direction of motion of the flour and the lighter and smaller particles are blown to another outlet. By varying the disc speed and the direction and velocity of the air we

can exercise considerable control over the particle-size separation point. Commercial units now available include widely varying refinements ranging from a fairly close approximation of this diagram to units which are essentially cyclone dust collectors with special provision for control of the maximum particle size retained.

Figure 2 demonstrates why this separation is useful with wheat flour. The top photomicrograph shows a HRW wheat flour as produced by conventional roller milling. There is a great variety of different size particles present: large endosperm chunks, small particles of free protein, free starch granules, and small chunks of protein plus starch granules.

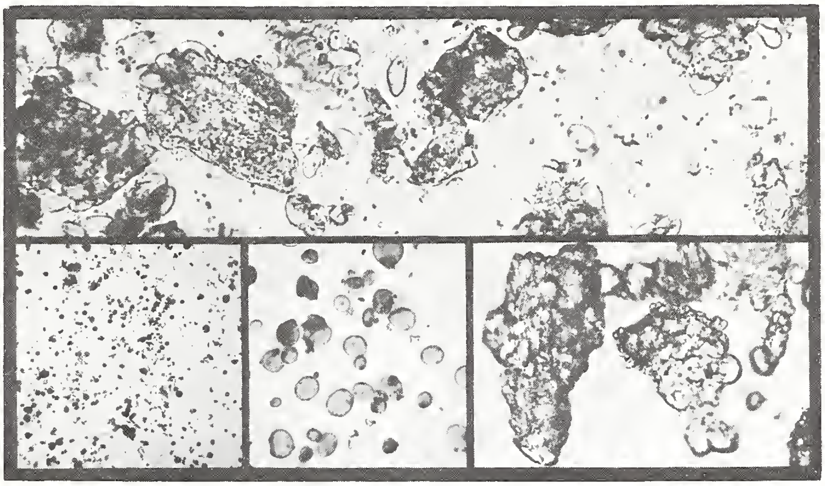

Figure 2. Photomicrographs of air classification of a commercial hard red winter flour (top) into typical fractions (bottom); finest--23.5% protein (left); intermediate--5.1% protein (center); and residue (right).

Air classification can separate these according to particle size, density, and shape into the three typical fractions shown in the three lower photomicrographs. The finest fraction, bottom left, is the high-protein fraction, with a particle size up to 15 microns. This sample contains 23.5 percent protein. In the center is the starchy fraction, with a size range of 15-30 microns. It contains 5.1 percent protein. On the right is the coarse residue remaining after removal of the fines. It has a size range of 30-125 microns.

Air classification of flour thus offers a means to concentrate the protein or starch and thereby produce fractions much richer or poorer in protein than the original flour while providing some control of particle size. The amounts of the high-protein and starchy fractions can be increased by subjecting the whole flour or the coarse residue to additional grinding to free more protein and starch particles.

Each passage of flour through classification equipment splits it into a finer fraction and a coarser fraction. Thus the miller must use at least two passages through air-classification units to recover the three products shown in Figure 2. Air classification can be used on ordinary roller-milled flours, on individual flour streams which the miller finds most appropriate, or on flours

that have been fine ground. Each miller has his own special needs, depending upon the wheats most economically available at his mill and the product mix he requires. Hence, the individual use made of this technique and the mill streams to which it is applied will vary widely from mill to mill.

Figure 3 shows one procedure for fractionating a relatively low-protein HRW wheat into three fractions. The milled flour is passed to a classifier set at a coarse-cut point--40 microns--and a coarse residue (F3) consisting mainly of endosperm chunks is separated from a fine fraction consisting of free protein, free starch granules, and small endosperm chunks. The fine fraction is ground to break up the small endosperm chunks, and the resulting product is passed to a classifier set at a fine-cut point--about 15 microns--to separate a fine fraction (F1) containing 18-22 percent protein. The residue (F2), which contains 5 to 8 percent protein, would be suitable for a cake flour. The level of protein in this fraction and the yield are determined by the intensity of the fine grinding. A bread flour of higher protein content than the original flour could be obtained by combining the high-protein fraction (F1) with the first coarse residue (F3).

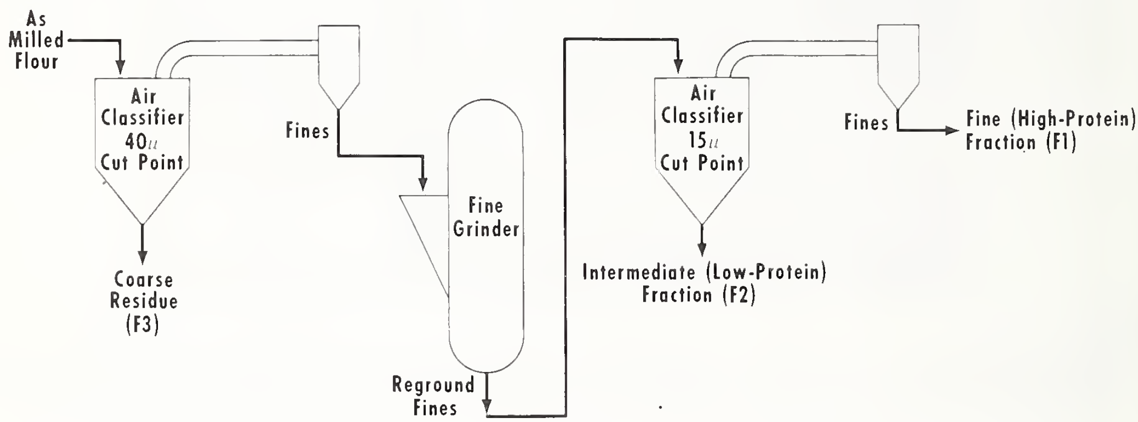

Figure 3. Modified air-classification procedure for hard red winter wheat flour.

This process is an oversimplification of any mill operation, since it is unlikely that all flour streams would be combined prior to fractionation. Other arrangements of the sequence could be employed to vary the types and yields of products, depending upon the miller's objectives.

Flour fractionating is relatively inexpensive. The cost of a procedure such as that shown in Figure 3 would be of the order of 10 to 15 cents per 100 pounds of flour in a plant processing 10,000 pounds of flour per hour, depending upon the degree of grinding, the type of flour processed, and the products desired. This procedure is economical where the products are upgraded to this extent or where the procedure permits use of a local wheat and thereby reduces transportation costs.

Different types of wheat vary markedly in their response to air classification. There is a considerable difference between fractionating a hard and a soft wheat flour. Figure 4 shows air classification results obtained under comparable conditions from typical Kansas HRW and Indiana SRW flours. For each flour the fine fractions having protein contents higher than the original flour

are represented by the first bar; the intermediate-sized fractions with protein contents below the original flour, by the second bar; and the coarse residue remaining, by the third bar. Yields of high- and low-protein fractions from the hard are lower than those from the soft wheat flour because of failure of roller milling to break the hard wheat endosperm chunks down to small fragments of free protein and free starch granules to the same degree; 60 percent of the hard wheat flour remained as residue versus only 23 percent of the soft.

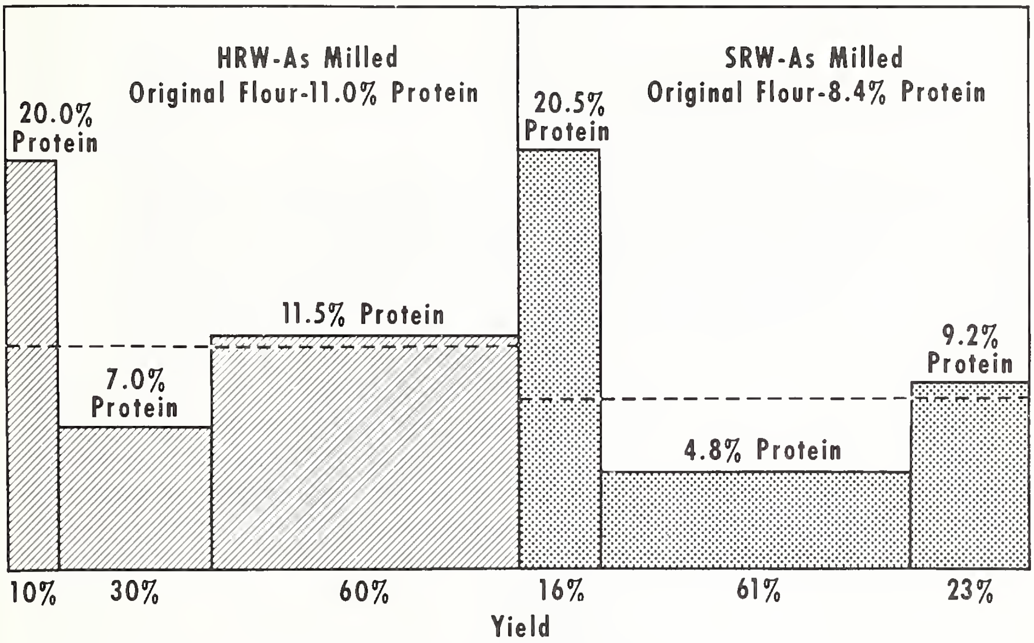

Figure 4. Air classification of hard and soft wheat flours.

Figure 5 shows how yields of the high- and low-protein fractions from a HRW flour can be increased by fine grinding to break up the endosperm chunks into separate starch and protein particles. Grinding is carried out in some type of impact or pin mill, such that the starch granules are not greatly damaged, since starch damage would downgrade the starchy fraction for many uses. In this case with fine grinding the yield of high-protein fraction from a HRW flour containing 12.2 percent protein was increased from 11 to 22 percent, and the yield of the lower protein fraction from 44 to 61 percent, with increase in the protein content of the fine fraction to 22.6 percent and with reduction to 7.6 percent protein in the intermediate fraction. The coarse residue dropped from 45 percent of the original flour to 17 percent of the reground flour.

Figure 6 shows increased yields of high-protein and low-protein fractions from soft red winter wheat obtained by fine grinding. The yield of high-protein fraction was increased from 16 to 24 percent and the yield of the low-protein fraction was increased from 61 to 70 percent, whereas its protein content dropped to 3.7 percent. The residual coarse fraction over 35 microns in diameter was almost eliminated.

Figure 7 compares the protein variation obtainable by fine grinding and air classification of a HRW flour with the protein in the various flour streams

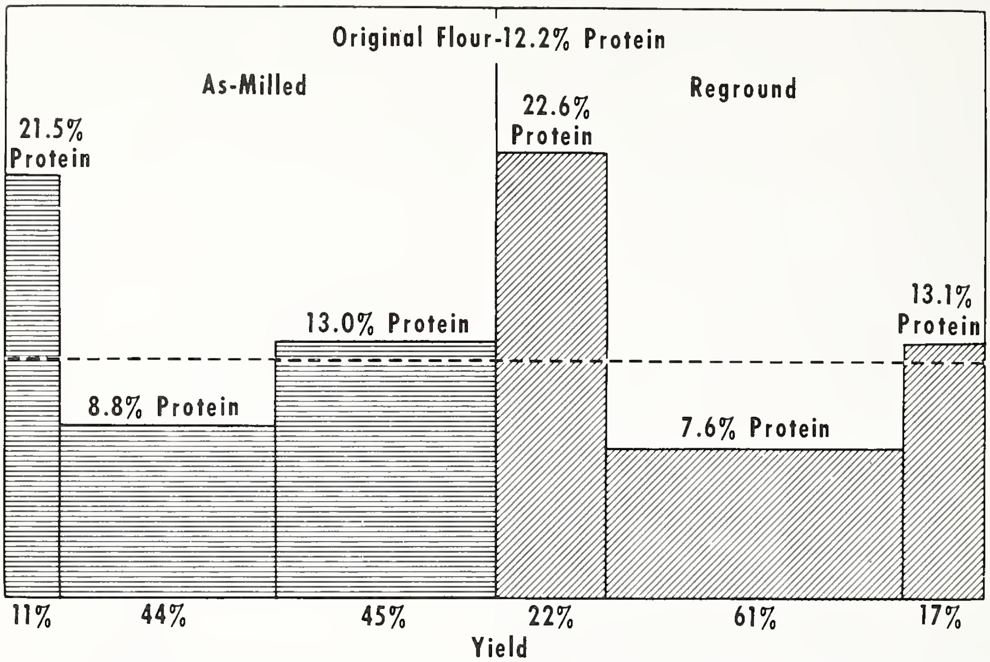

Figure 5. Fractionation of flour from midwestern hard red winter wheat.

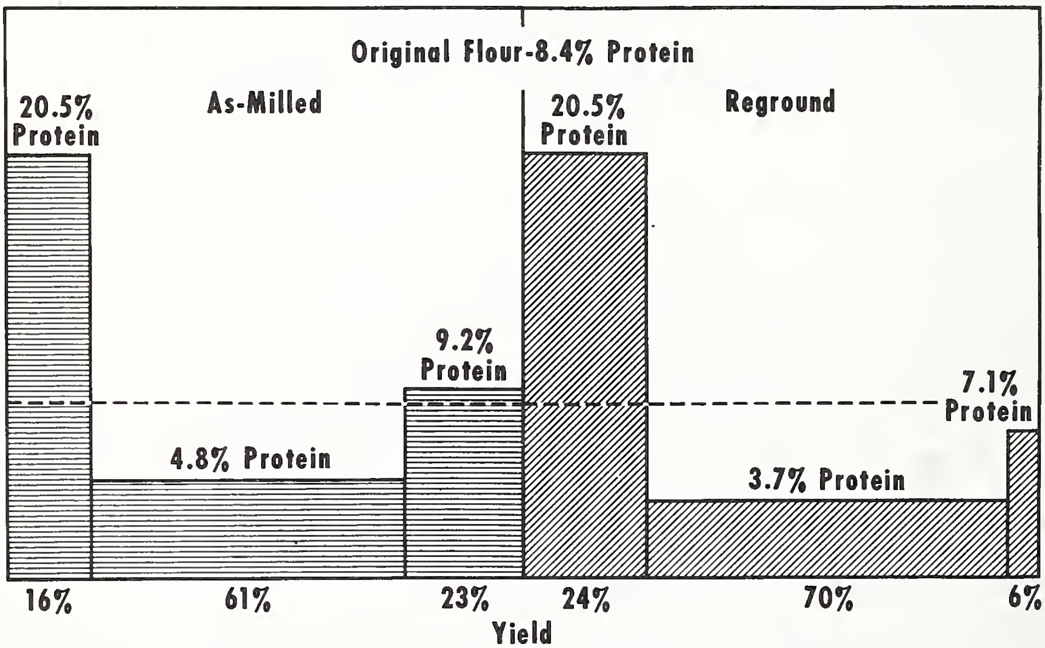

Figure 6. Fractionation of soft red winter wheat flour.

separated from the same wheat during conventional milling. The fractions or streams are arranged according to increasing protein content, plotted as a function of the percent of total flour. Conventional roller milling of this wheat provides flours of only a limited range of protein content, from about 10.6 to 18.4 percent. The higher protein materials are obtained from the latter

break rolls with correspondingly high ash contents. In the fine grinding and air classification of the straight flour from this wheat, the fractions varied in protein content from 7.2 to 26.5 percent. Nearly half of this flour can be obtained with a protein content below 8 percent, and having a fine granulation suitable for cakes and pastry. Over one-fourth of the flour can be obtained with a protein content of 20 percent or higher. Thus, fractionation of this flour can greatly increase its range of uses.

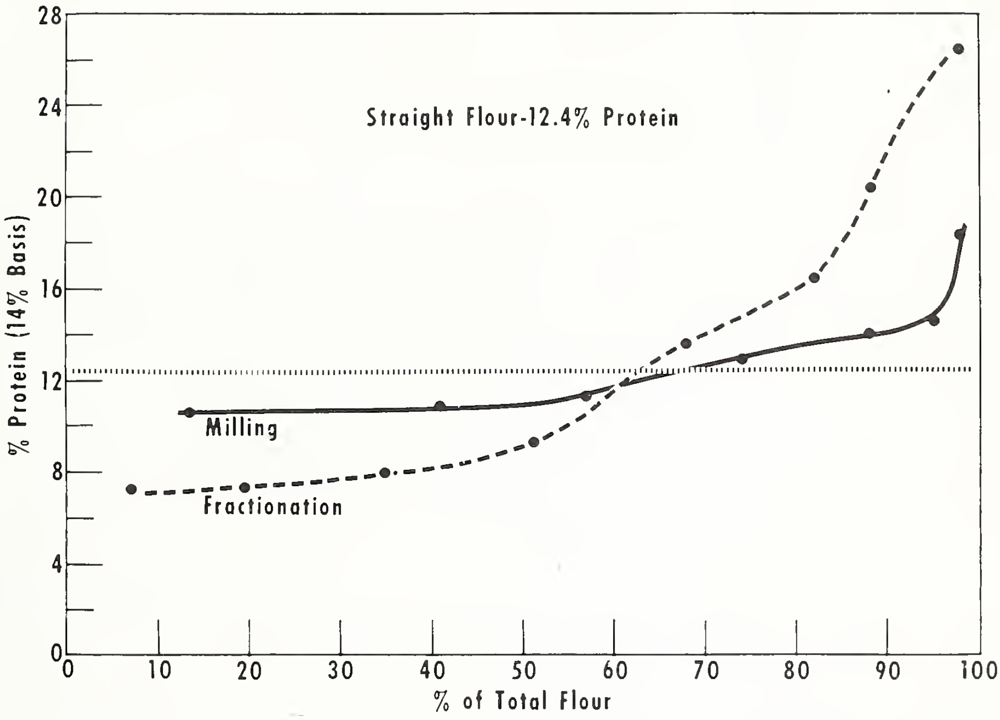

Figure 7. Comparison of protein ranges from hard red winter wheat flours obtainable by wheat milling vs. flour fractionation.

Table 1 shows the range of fractions obtained from typical hard and soft flours by fine grinding and air classification. Some generalizations can be made in comparing the ease of fractionation of flours from different classes of wheat, but they mostly resolve into the relative ease of breaking up the endosperm into small protein fragments below 15 microns in size and unbroken free starch granules in the 15-35 micron range. Soft wheat flours have been the most readily fractionated, and they have yielded a greater range of fractions than hard red winter and hard spring wheat flours, which follow in that order.

The types of wheat in Table 1 are listed in order of increasing protein content. As expected, the softer, very low-protein flours tend to give lower protein products, but the higher-protein flours have more protein in both their highest and lowest protein fractions.

Most of the high-protein fractions would be useful for flour fortification to increase strength, absorption, and baking properties of flours deficient in these respects. The low-protein fractions are suitable for use in cake, cooky, and pastry flours or possibly for industrial starches if their price

would permit. Coarse residues remaining after removal of these fine fractions are useful for bread, cookies, and crackers, depending upon protein content.

Table 1. High- and low-protein fractions separated from various flours

Wheat flour			Protein in fraction, %	
			High-protein	Low-protein
PNW area	WC	(6.0% P)	17.0	2.2
Michigan	SWW	(7.9)	20.2	2.8
Indiana	SRW	(8.4)	25.1	2.7
Illinois	SRW	(9.8)	23.5	4.6
Midwestern	HRW	(12.2)	25.8	6.9
Northern	HRS	(13.3)	26.4	7.8

Even within a given class of wheat, variety plays an important part in response to flour fractionation. Table 2 shows the range of fractions obtained from several midwestern HRW wheats when their flours were classified by a repetitive procedure. The value listed in the last column as "protein shift" is the sum of the protein that is shifted into the high-protein fractions plus that shifted out of the low-protein fractions expressed as percent of the total protein in the starting flour. This index is useful for measuring the relative response to fractionation of different flours and the effectiveness of different procedures used in the fractionation, since it takes into consideration both yields and protein contents of the fractions and relates the protein shifted to the total protein present in the flour.

Table 2. Fractionation of flour from leading varieties of midwestern HRW wheats

Variety	Percent protein in			Protein shift, % of total
	Orig. flour	High-P fraction	Low-P fraction	
Bison	10.8	31.7	4.6	60.4
Triumph	10.6	28.2	4.3	58.6
Wichita	11.0	29.4	5.4	49.9
Comanche	12.8	30.1	6.5	39.2
Pawnee	9.2	22.1	4.9	36.3

For these tests all individual wheats were milled, and their flours fine ground and fractionated under the same conditions so that the results shown are directly comparable. The amount of protein shifted was highest for the Bison flour and dropped as we go down the table. As would be expected, the protein content of the low-protein fraction tended to be lowest where the best fractionation was obtained, except for the Pawnee wheat that had an unusually low-protein content in the original flour.

This table shows that small high-protein fractions from HRW wheats may contain over 30 percent protein and that low-protein fractions, below 5 percent, are obtainable. In these and other studies, Bison, Concho, Triumph, and Wichita flours have responded well to fractionation; Comanche, Pawnee, and Ponca were more difficult.

At the Northern Laboratory we have been particularly interested in separating low-protein fractions for use as industrial starches, or other

fractions that may have unusual value for specific industrial uses. For many potential nonfood uses, such as paper, gypsum board, adhesives, and sizes, the high-starch fractions might be expected to have about the same value as other cereal products of comparable protein content. For these types of use, a low-protein content is desirable. A figure of 3 percent protein has sometimes been mentioned as the maximum tolerable for many industrial uses without chemical treatment to modify the protein properties, although the acceptable protein content will differ for specific uses.

Table 3 shows the amounts of low-protein material obtainable by reprocessing starch fractions produced in the initial classification of various typical flours. That is, the starchy fraction has been fine ground and reclassified. Pacific Northwest soft white wheat can yield 56 percent of a 2 percent protein material or 68 percent of a 3 percent protein fraction. The Michigan soft white wheat flour yields up to 58 percent of a 3 percent protein fraction, and the Indiana soft red wheat flour yields 61 percent of a 3 percent protein fraction. The hard wheats did not give fractions in the 3 percent protein range although some yield of fractions in the 5 to 6 percent range, not shown, would be possible.

Table 3. Effect of flour type on yields of low-protein fractions (reprocessed blends)

Wheat flour	Yield, % of original flour 2% Protein	3% Protein	4% Protein	7% Protein
PNW area, SWW	56	68		
Michigan SWW	40	58	64	
Indiana SRW	20	61	66	
Midwestern HRW	0	0	0	43
Northern HRS	0	0	0	42

Some specific examples of how fine grinding and air classification of wheat flour may be applied are listed in Table 4. The principal applications fall into two main categories--adjustment of protein content and control of granularity. Under protein content adjustment, by selecting the proper fractions, we can produce industrial starch fractions from soft wheats.

Table 4. Applications of air classification

A. Adjust protein content for specific uses
   1. Industrial starch fractions
   2. Bread flour from low-protein wheat
   3. Cake flour from high-protein wheat
   4. Specialty high-protein flours

B. Control granularity for specific uses

Bread flour is now being made from low-protein hard wheats in certain HRW areas by removing a starchy fraction suitable for cake baking. The remainder of the flour is thus improved in protein content and bread-baking performance. The cake flour produced at the same time provides a second product, which commands a premium price.

In certain SRW areas cake flour is made from high protein soft wheats by removing a high-protein fraction and coarse material, leaving a cake flour of

the proper granularity and protein content. Similarly, cooky flours are made by removing a high-protein fraction, which controls both the granularity and protein level of the cooky flour. A similar procedure could be used with HRW flours of higher protein content than desired for bread. Removal of a high-protein fraction could leave a bread flour of controlled granularity and protein level. The high-protein fraction could then be used elsewhere.

Higher protein flours for hard rolls and specialty breads can be prepared by blending back high-protein fractions to normal flours. Under granularity control, applications exist in controlling optimum particle size for bread, cooky, and cake flours, as well as for flours for possible industrial purposes.

Table 5 summarizes conventionally milled flours from certain wheats and additional flours that can be produced from them by fractionation. Emphasis here is essentially on the hard red winter wheats. I have not tried to itemize all the soft wheat types or products separately. Products available from individual HRW wheats are broadened, but this process would be most applicable to the lower-protein HRW wheats, since the higher-protein flours usually are good for bread, as milled. In addition to yielding a further range of products from individual soft flours, fractionation of these flours can yield low-protein fractions of potential use as low-purity industrial starches.

Table 5. Flour fractionation products

Wheat	Conventional milling products	Possible flour fractionation products
HRW (good protein content)	Bread flour (11.5% min. protein)	High protein specialty flour Bread flour Family flour Cake flour
HRW (moderate protein content)	Family flour (lower protein)	High protein specialty flour Bread flour Family flour Cake flour, biscuit & cracker flour
Soft wheats	Cake and cookie flour	Protein fraction for fortification Family flour (some HW flour required) Improved cake and cookie flour Starch fraction (3% protein)

Some of the factors affecting the response of flour to fractionation are listed in Table 6. Class and variety of the wheat have been shown to be very important. Our studies have shown that the growing conditions of a specific lot of wheat can also influence its response to fractionation. Of these, location is very important, but variations caused by weather and soil conditions can be quite large.

Classification response will be increased by any treatment of the wheat or flour that tends to free the starch granules to a greater extent. The type of flour--that is, whether it is a break flour, middlings, a patent flour, or a straight flour--also influences response. With hard wheats, short patent

flours usually yield lower-protein fractions than break flours, but with soft wheats break flours usually yield lower-protein fractions. Flours become more friable when they are dried before fine grinding and, therefore, will release starch and protein more readily.

Table 6. Factors affecting flour fractionation

1. Wheat:
   Class
   Variety
   Growing conditions (climate, location, fertilizer, irrigation, etc.)
2. Milling of wheat:
   Conditioning
   Type of flour or mill stream
   Flour treatment
3. Fractionation:
   Intensity and type of grinding
   Efficiency of classification
   Sequence of operations

The intensity of grinding determines the amounts of free starch and free protein that are released from the endosperm chunks and are available for segregation. If a bread flour is desired from a low-protein hard-wheat flour, only enough fine grinding is used to permit separation of sufficient low-protein material to raise the protein content of the remainder to a bread-flour level. To produce a cake flour from a soft-wheat flour that is high in protein, the intensity of fine grinding is controlled to yield the desired amount of low-protein cake fraction at the proper protein level. To produce starch for industrial purposes (that is, 3 percent protein or less) additional fine grinding can be employed upon the low-protein fraction to break loose more protein for removal by reclassification.

The efficiency of the air-classification system used can materially affect the range of protein contents and the yields. Also the sequence of operations can be changed to control the products obtained. Since different varieties and types of wheat differ significantly in their response to fine grinding and air classification, response to fractionation represents another aspect of wheat quality to be considered by breeders, growers, millers, and bakers. Many experts in these fields feel that although air classification places somewhat less importance on the <u>protein level</u> of wheat, it increases emphasis on the <u>quality</u> of that protein.

In summary, some <u>advantages of flour fractionation</u> are the ability to:
Produce more uniform products from varying wheats,
Increase protein content for a bread flour,
Decrease protein content for cake and cooky flours,
Control low-particle size for cake flour,
Control granularity for bread, cracker, and cooky flours,
Save transportation costs for blending wheats and cross shipping flours,
Produce specialty flours of higher protein than previously available,
Produce low-protein starchy flours for use as industrial starches,
Possibly control oil, ash, and maltose values in some flours.

The extent to which flour fractionation will be used in the future is still unanswered, and in some locations it may have little or no advantage. Fractionation costs must be balanced against transportation costs and with costs of competing materials. Several products usually result from the process, and these must all be used.

With air classification it is now possible to produce from HRW wheats most of the typical flours produced by conventional milling from both hard and soft wheats. With present and future advances in milling and fractionation techniques, it should be possible to produce an increasing variety of flours and other raw materials for food and industrial uses.

Discussion: It was added that blending back the high protein fractions to a bread flour can increase the absorption. About 10 percent addition may be as much as is profitable to use.

FOOD AND FEED VALUES IN WHEAT PRODUCTS

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The title of my talk may sound like a chapter of a book on nutrition or perhaps like a paragraph in an encyclopedia. I do not intend to be either academic or encyclopedic. I intend to point out some of the unsolved problems in food and feed values of wheat and to describe some efforts which are being or should be made to solve these problems. First I should like to consider feeds for animals.

Why worry about wheat feeds? Wheat is too expensive to feed to animals and there are plenty of people around the world who are ready and willing to use all the wheat they can get their hands on. There are large markets at home which have been lost but which might be regained when research solves the problem of getting to the consumer a loaf with stabilized oven-fresh flavor.

I was confronted by these comments one day when I told a visitor that we are doing some work on wheat feeds. I pointed out that although we have some interest in wheat grain as feed, our primary interest is in by-products of flour manufacture. For every 72 pounds of flour produced from wheat the miller makes 28 pounds of wheat mill feeds. If these feeds cannot be sold at a fair price, there are only a few alternatives: (a) the price of flour must go up; (b) the price of wheat must go down; or (c) the miller must go broke. Looking back at price changes which have occurred we find that the squeeze has been on ever since World War II. My first table shows that the price of mill feeds has

Table 1. Price trends in wheat products

	Wheat ($/T.)	Mill feeds ($/T.)	Flour ($/T.)
1950-54	77	50	124
1955-59	70	35	118
1960-61	69	34	110

dropped badly in this period. The price of flour did not go up but stayed roughly proportional to the price of wheat, which went down.

Table 2 gives a general idea of what this trend did to the miller. Here I have applied the prices I have just shown you to the milling of 10 tons of wheat. The shifts in price did <u>not</u> balance up, and so the miller has taken a beating just as the farmer did. His margin to cover all operational and fixed costs as well as his profit shrank from $260 to $187 per 10 tons of flour. The repercussions in the milling industry have been apparent. We have seen changes in personnel, efforts to cut costs, efforts to diversify, and failure of some companies in the milling business.

Table 2. Approximate value of mill products from 10 tons wheat

	1950-54	1960-61	Difference
Flour	$ 890	$790	-11%
Mill feeds	140	90	-43%
	1,030	880	
Cost of wheat	770	693	-10%
Margin	$ 260	$187	-28%

Those of you who read Lil Abner will remember Ole Bull Moose. He was a tycoon who believed that what was good for Bull Moose was good for the country. I don't think that everything that is good for the miller is necessarily good for the farmer, or vice versa, but I do know that a development like this one is not good for either. The farmer, the elevator operator, the miller, and the baker are all in this together. When we realized what was going on several years ago, we initiated a modest amount of work on mill feeds with the object of trying to shore up this weak spot in the wheat "agribusiness."

Today I will first describe briefly what the currently available mill feeds are and some reasons for the price weaknesses which have developed. Next, I will describe the bran layers of wheat and an approach to improved products. Then, I wish to discuss in some detail research on upgrading of wheat products which was carried out under our contract with Washington State University. Finally, I will describe the development of linear programming for least-cost rations and its implications for feed ingredient suppliers.

Table 3 shows the types of wheat feeds which are currently available to the feed manufacturer. The flour milling operation consists of tempering to toughen the outer layers and then gradually reducing particle size by alternate rolling and screening. As the size is reduced the character of the screen "overs" changes as evidenced by changes in ratio of protein to fiber and fat.

Table 3. Some mill by-products

	Hard red spring	Hard red winter
Coarse (40%)	A. Bran	D. Bran
Medium (40%)	B. Standard middlings	E. Brown shorts (red shorts)
Fine (20%)	C. Red dog	F. White shorts (white middlings)

B+C = wheat flour middlings
E+F = gray shorts (gray middlings; total shorts)
A+B+C = wheat mixed feed or "mill run"

There may be a hundred streams in a mill. A mill operator may combine the various streams to give an array of products. Mills operate somewhat variably but a common yield of bran might be 40 percent of the nonflour products (11.2 percent of the wheat). In addition, spring wheat might yield about the same amount of middlings and about half as much red dog. The comparable

fractions from hard red winter wheat have different names: "brown" or "red shorts" instead of standard middlings and "white shorts" or "white middlings" instead of "red dog." It seems there should be a product in this array with the name "short-haired, middling-sized, white dog" but I haven't run across it yet. If the finer fractions are combined, the products from spring and winter wheat, respectively, are wheat flour middlings and gray shorts. Some mills simply mix all of the streams together and call the product "mill run" or "wheat mixed feed."

Let us take a look now at the reasons for the 20-year slide in mill-feed prices. First, the mill feeds are relatively high in fiber. Cattle and sheep can digest fiber with the help of the bacteria and protozoa in their rumens. Poultry and swine cannot. Hence, the trend to high-energy, high-efficiency rations for these non-ruminant animals has led to loss of a large market for mill feeds. Second, there has been a big drop in the prices of feed grains and a large increase in the production of sorghum grain. Both corn and sorghum grain have been sliding downward in price and have undoubtedly dragged the prices of mill feeds along with them. This is an illness which research on mill feeds cannot mend. But, if we can do something to wheat products to improve their value to livestock and poultry, their much higher protein and vitamin contents should help to keep mill feeds at prices which would be healthful for the wheat industry.

Let us consider a microscopic section of a kernel of wheat. The central portion is the endosperm, which consists largely of starch granules embedded in a matrix of protein. It also contains a small percentage of cell walls. In the milling process we try to separate the endosperm from the aleurone layer, the bran layers, and the germ. All of the commercial mill feeds I have described contain some of all the parts of the kernel but the products contain relatively different proportions. Since the combined outer layers and germ amount to only about 15 percent of the weight of the kernel and since commercial mill feeds amount to 28 percent of the wheat, it is obvious that almost half of the mixed mill feeds is endosperm.

One approach to increasing returns from wheat is to recover the 15 percent of flour in the mill feeds. An approach to upgrading mill feeds is to separate the bran layers and to investigate their biological value. The end-point would be to develop economic methods of separating protein-rich, energy-rich products from mill feeds for use by poultry, swine and perhaps human beings. The residual high fiber products would be used in ruminant feeds. We are undertaking exploratory work along this line in cooperation with one of the large milling companies.

The second approach we have taken was suggested by research on upgrading of barley by McGinnis and Jensen of Washington State University. These workers had found that when barley was fed in place of corn in broiler rations, growth was reduced by as much as 25 percent. Feed efficiency was similarly depressed, the chicks were sickly, and their droppings were wet and sticky. Later they found that barley was causing pancreatic enlargement and other changes in the chicks. Then the rather surprising discovery was made that these deleterious effects could be virtually eliminated by soaking the barley in water and redrying it in a laboratory oven. Note that no part of the barley was removed.

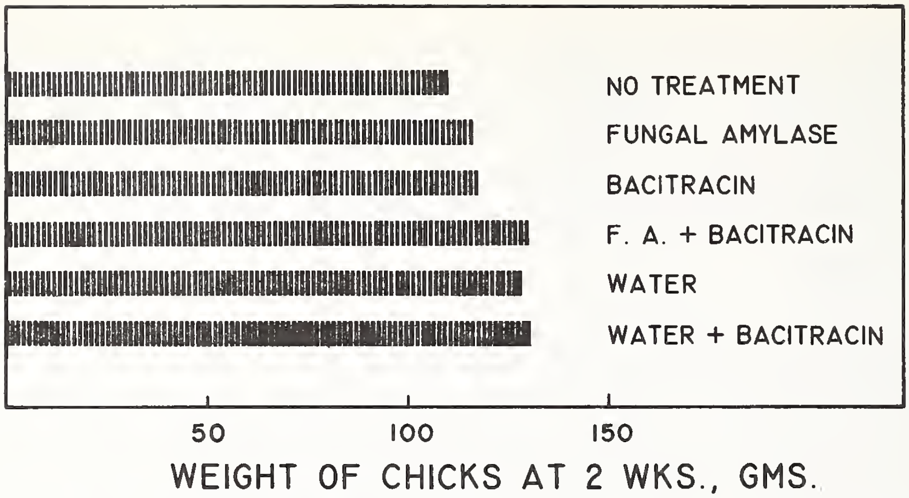

Figure 1. Improvement of nutritional value of barley by various treatments.

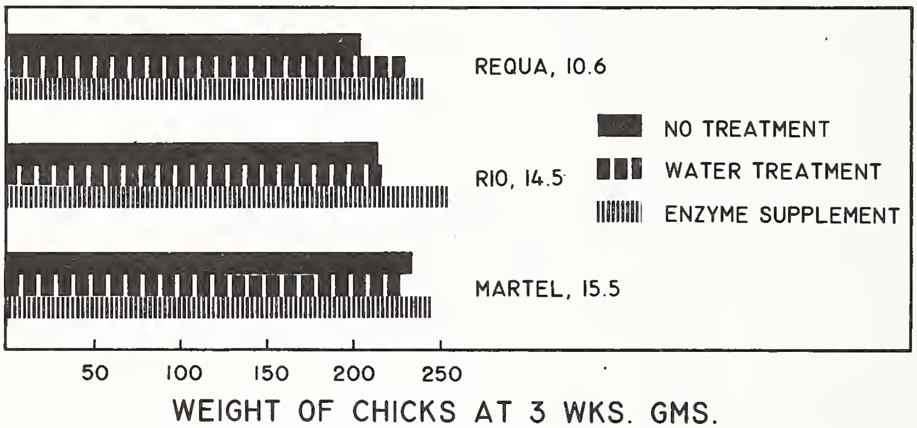

Figure 2. Effects of water treatment and enzyme supplementation of three varieties of wheat on their nutritional value.

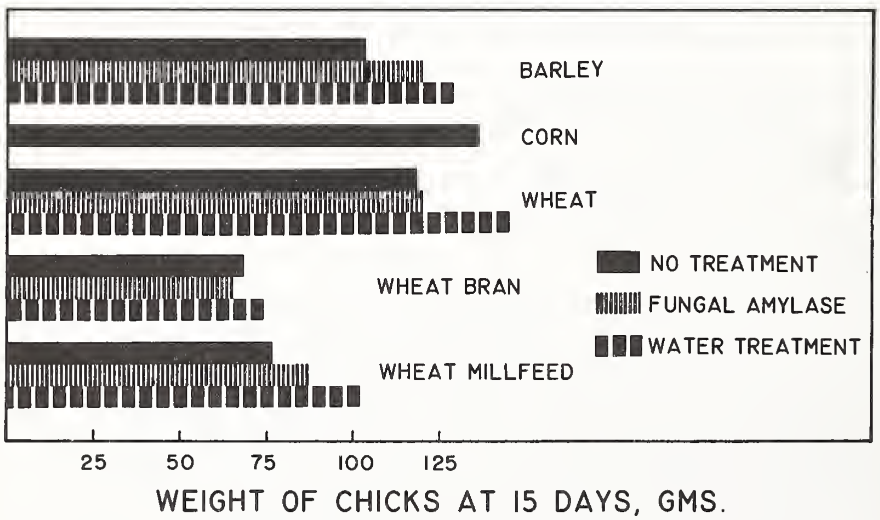

Figure 3. Improvement of barley, wheat and mill byproducts by water treatment or enzyme supplementation.

The whole mass was simply dried. They then found that adding certain enzyme preparations or adding fat to the ration partially corrected the defect in barley. Our research responsibilities includes feed uses of barley as well as feed uses of wheat. We therefore developed a contract project with Washington State University to extend this work along the following lines: (a) to find out how and why the "water treatment" worked on barley and (b) to extend the work to wheats and wheat mill feeds to find out if their nutritional value could be similarly improved. I think you will be interested in some details of this work. It has some of the characteristics of a detective story but here we are hunting for the "good guy" or what improves grains.

The facts that fat and enzyme supplement improved growth provided a clue that something was wrong with energy availability. The problem seemed to be: How could simply wetting and redrying do the job? An exhaustive study of conditions of soaking and drying showed first that time of soaking made essentially no difference. The improvement was being effected in the redrying step. Next it was found that the slow drying as carried out in the laboratory oven seemed necessary. As drying was speeded up by raising oven temperature above 160°F., poorer and poorer results were obtained. This evidence pointed to microbial fermentation taking place during the drying step.

To find out whether this was true, experiments were carried out on barley sterilized by autoclaving or ethylene oxide treatment. It was found that these treatments blocked the improvement and indicated bacterial infection. Next, tests were made to see what was happening to the bacterial population during treatments. It was found that during water treatment there was a tremendous increase in bacterial count. One of the dominant types present was a rod-shaped organism similar to *Bacillus subtilis*. This organism was isolated and cultures were added back to sterilized barley. Then it was found that water treatment was again effective. Now this type of organism is known to elaborate antibiotics as well as enzymes. Experiments showed that a combination of fungal enzyme plus bacitracin can do essentially the same job as water treatment (see Fig. 1).

The work I have described was done on Pacific Northwest barley. When reports on the work began appearing in the scientific literature other workers, of course, began to check barleys in their areas and it soon became evident that all barleys do not act alike. Accordingly, Jensen and McGinnis surveyed barleys from a wide geographical area. The results showed that variety was not an important factor but that eastern barleys were superior to western without water treatment or supplementation with enzymes and antibiotics and responded less to these treatments. It seems likely that because of higher humidity or wetting by rain in the field, the eastern barleys had greater microbial growth on the kernel prior to and during harvesting. Autoclaving eastern barleys to destroy enzymes makes them respond like western barleys to enzyme treatment.

Let us turn now to wheat and mill feeds. A survey of western wheats showed that they respond like barleys. Typical results are shown in Figure 2. Studies of mill feeds show that they too respond to water treatment and are improved. Even bran (Fig. 3) which contains the highest level of cellulose, becomes a fairly good feed. At low level it could be affectively used but at high levels (about 60 percent) even the water treatment could not overcome its low energy content. This points again to the need for a fiber separation process.

Where do we stand now in this problem? First of all, we do not know what specific material in wheat products and barley is being acted upon. We know it is not starch, per se, because specific starch splitting enzymes are not effective. We need to know more about the nonstarch carbohydrates of all of the products from wheat and their susceptibility to various enzymes. It may well be that there is a much greater potential for increasing the nutritive value of these products than we have yet seen. In this connection it has been reported by Maryland workers that wheat germ and wheat middlings contain toxic factors which are destroyed by autoclaving. In our own preliminary experiments we find that fairly high levels of wheat germ do not inhibit growth of chicks. It may well be that under some conditions organisms may be growing on wheat which produce toxic principles. Reports of toxic corn and peanuts have already appeared.

My discussion thus far has provided a background for the next topic I would like to discuss--that is, linear programming for least cost feeds. We live in the electronic age and computers have already invaded the feed field. For years the feed formulator has shifted his formulas as price of ingredients shifted. He based his shifts on knowledge of nutritional equivalence of various ingredients. This knowledge included only major factors such as crude protein, fiber, energy, etc. He couldn't possibly bring into his calculations such items as the contents of all essential amino acids, vitamins, and all minerals. He could only overwhelm variations in these factors by putting excesses of protein, vitamins, and minerals in the ration. In order to utilize all the natural ingredients in feedstuffs he would have had to solve thousands of simultaneous equations involving hundreds of variables. This is an impossible task for a man with a slide rule or a desk calculator. But the electronic computer can handle the mass of data in less than an hour and is being put to the task. This means that for the first time it is theoretically possible to determine the intrinsic value of a feedstuff based on current markets for competitive sources of nutrients. In turn, it means that each ingredient supplier must know as far as possible what is of value in his product. He must further be certain the nutrients present are biologically available. In the case of wheat mill feeds, for example, the research I have described earlier points a way to increase the intrinsic value of the carbohydrate fraction and improves their competition status. More work is needed to carry this aspect farther, to extend it to other nutrients such as the essential amino acids, vitamins, etc., and to develop products specifically designed for specific types of livestock. The time is rapidly passing when a feedstuff is used because of tradition.

So much for wheat products as feeds. Research on human nutrition in the USDA is the responsibility of the Human Nutrition Research Division in Washington and Beltsville. However, we in utilization research are keenly interested in making certain that the processes we develop are designed so as to yield products with maximum nutritional value. It is well known that excessive heating of cereals in breakfast food manufacture results in a loss of available lysine. Even though human requirements are relatively lower for lysine than that of animals, the margin of safety in high-cereal diets is not large. We therefore considered it important to determine whether the process of converting wheat to bulgur would affect lysine availability. Since bulgur is expanded by a dry heat prior to making shelter rations and other new foods, we checked the effect of this puffing operation on lysine availability. There is at

present no proved chemical method of determining lysine availability in cereals. Indeed, we are sponsoring a P.L. 480 project in England to develop such a chemical method.

We therefore had to rely on a bioassay. The chick has a high lysine requirement and an extraordinary growth rate and so we used chicks for the study. We found that the same amount of added lysine was required to meet the chick's requirement when wheat, bulgur, or puffed bulgur was used as the energy source in a lysine-deficient ration. This shows that lysine availability was not affected by the treatments. You will notice, however, that at each level of lysine the bulgur-fed birds grew better than the birds fed raw wheat. Also, at each level of lysine the birds fed puffed bulgur grew less well.

This shows that some factor other than lysine was affected by the treatments. In a second experiment designed to check this point the results showed the same trends but were less striking. We do not know whether the improvement is related to the Jensen and McGinnis effect or not, nor do we know that it is important in human nutrition. We are planning to look further into the matter using different types of wheat.

I see that my time is about used up so I should like to close with a few summarizing remarks and conclusions. First, the entire wheat industry has an economically important problem in mill feeds. It is essential that we gain knowledge on how to make products from the nonflour portion of wheat with the maximum intrinsic nutritional value for specific end uses. The development of linear programming for least-cost feeds makes it essential for producers of all feed ingredients to re-evaluate the processes and products in order to maintain or expand markets. Second, the discovery that mill feeds can be improved by processing and specific supplementation points to a need for their re-evaluation in commercial rations, especially for poultry. Finally, development of new foods must be based on sound nutritional investigations as well as such factors as flavor, texture, and appearance. Experiments with bulgur show that lysine availability is not affected by the processing, but that, for chicks, the processing actually seems to improve the overall nutritional value.

Discussion: The strain of B. subtilis observed in the grain nutritional modification tests observed did not form a slime under the conditions of the experiment.

BREEDING WHEAT FOR IMPROVED QUALITY

Panel discussion by: L. P. Reitz, Agricultural Research Service, U. S. Department of Agriculture; A. M. Schlehuber, Department of Agronomy, Oklahoma State University; Paul Mattern, Department of Agronomy, University of Nebraska; K. F. Finney, Hard Wheat Quality Laboratory, USDA; M. A. Barmore, Western Wheat Quality Laboratory, USDA.

Opening Remarks (L. P. Reitz). Food use is by far the largest outlet for wheat. Aside from its high nutritive content, its most unique property is gluten, which in great part accounts for the choice of wheat over other similar food products. Wheat varies through wide limits in both chemical composition and behavior properties. In fact the percentage composition in protein, minerals, enzymes, and vitamins may show 3-fold, or greater differences among lots of wheat. These differences have far-reaching effects and become the basis for what is loosely referred to as quality, whether we are concerned with nutrition, processing, or costs.

Potential quality is the sum of the many influences that bear upon the wheat plant and the kernel during its formation; actual quality is seen in the food set before you. We are concerned in this panel with potential quality because this is related to agricultural and genetic factors. The primary modifiers of quality are soil, climate, and seed stock.

The soil has great influence on wheat quality, especially at extreme levels of depletion and fertilization. This is especially true of level of protein and mineral composition. The soil is in a basic sense a product of climatic factors working on parent rock and other soil-forming materials so that soil and climatic effects are often seen together. In a famous experiment conducted half a century ago, soil was moved from one state to another and wheat grown on it. The 4-year average of protein content for wheat grown on the same soil was 18 percent in Kansas, 13 percent in California, and 11 percent in Maryland. Some have concluded, erroneously, that the soil had no effect. The truth is that both soil and climate are basic before the third element--seed stock--can have any opportunity to be expressed.

Today, we will talk mostly about seed stock--the inheritance of quality, how high quality is detected and bred into new varieties--how it is retained during the breeding program. Quality is a loose term that is hard to define. Rather than be tied to the dictionary definition, I believe we will understand one another if we say wheat that is desired has good quality and wheat that is not desired has poor quality. Quality as used here consists of those properties of wheat and flour that are necessary to produce desirable bread, biscuits, crackers, cakes, cookies, pretzels, cones, macaroni, etc., at minimum cost. So, when a speaker today mentions quality, try to think with him in terms of quality for some use.

Q. Dr. Schlehuber, can breeding for quality be discussed on a national level?
A. Only in general terms. Some of the major problems of breeding wheat for

quality rest on the fact that different classes of wheat are produced in the North American continent. Overall wheat improvement programs divide rather logically according to types of wheat and region of growth. Quality must be considered in relation to classes and their general uses.

Q. What are the principal regions of wheat production in the U.S.A. and Canada?
A. The 4 principal regions are: (1) Hard red winter wheat region bounded roughly by Montana, Illinois, and Texas. (2) Hard red spring and durum wheat region comprising the 9 north-central states and adjacent area in Canada. (3) Soft winter wheat region from the Mississippi River to the Atlantic. (4) Western wheat region, west of the Continental Divide.

Q. Wheat development has been going on since before the turn of the century. How would you label the periods in wheat development in each of these 4 regions?
A. Let's consider them in my original order, first the Hard Red Winter Wheat Region. This region has gone through 4 major stages or periods. These I would call the (1) Covered Wagon period, c. 1850 to 1872; (2) Turkey period, 1873 to 1932; (3) Tenmarq period, 1933 to 1944; (4) Pawnee-Comanche-Wichita-Triumph-Kaw period, 1945 to the present. The Covered Wagon period was a trial-and-error period in which numerous types or classes, mostly soft red winter and hard red spring, were grown. Compared to the good adaptation of these classes in other parts of the U.S.A., these trials showed the generally poor adaptation of these classes in the Great Plains area, particularly in the central and southern parts of this area.

Q. You put Turkey wheat in a period by itself; this variety must have some special significance.
A. Yes. Turkey is the variety which founded the Hard Red Winter Wheat Region. Soon after Turkey wheat was introduced into Kansas by a small group of Mennonites in 1873, it was found to be superior over other wheats. By 1910 it occupied 99.5 percent of the entire hard red winter wheat acreage. Surprisingly enough it was not until 1944 that Turkey was superseded as the leading variety in the United States.

Q. Was the quality of Turkey wheat satisfactory?
A. Generally, yes. It was not Turkey which gave impetus to breeding for improved quality. It was the release of certain low-quality varieties during the late Turkey and early Tenmarq periods. These were: Blackhull, released in 1917; Early Blackhull, released in 1930; Chiefkan, released in 1935; Red Chief, released in 1940. While these wheats had numerous desirable agronomic characteristics, it was this series of wheats which "put the curse" on hard red winter wheat quality-wise.

Q. You also put Tenmarq into a special period. Why is that?
A. For three reasons: (1) I think it represents the first conscious attempt to produce a hard red winter wheat of improved quality with special testing equipment; (2) its quality was so satisfactory, along with fairly good agronomic characteristics, that it became for a short period the leading variety of hard red winter wheat; and (3) Tenmarq had to carry the main "quality load" during the heyday of well-adapted but low-quality wheats.

Q. Certain groups have recommended that Pawnee, once the leading variety of hard red winter wheat, be placed on the discount list because of its inferior

quality. Is its quality not as satisfactory now as when it was released?
A. Pawnee's quality hasn't changed. However, perhaps it indicates a "sign of the times" when we realize that once it was generally welcomed as a replacement for Chiefkan and Red Chief. I think it shows something about the overall quality improvement of hard red winter wheat. Of course at the time Pawnee was released no one could know of its good adaptation outside of the hard red winter wheat region.

Q. Where do we stand today?
A. The leading hard red winter wheat variety--and the leading wheat in the U.S.A.--is Triumph, an early-maturing mellow-gluten wheat.

Q. Is there a strong-gluten replacement for Triumph?
A. The word "replacement" includes factors other than quality--if it is to replace Triumph, it must have early maturity. Kaw wheat, only about 2 to 3 days later than Triumph, is a strong-gluten variety and is meeting with generally good acceptance in Kansas and Oklahoma.

Q. I believe that covers hard red winter wheat. How about the periods of wheat development in the hard red spring region?
A. Because of the extreme importance of damage resulting from stem rust, every important hard red spring wheat breeding program in North America has as its first objective the breeding of resistance to races of black stem rust, of which the most virulent has been race 15B. Consequently, progress in breeding for quality must be considered in relation to this major hazard. The periods in the hard red spring wheat area are roughly: (1) the Red Fife period, 1860 to 1914; (2) the Marquis (1915) and Ceres (1926) period, 1915 to 1935; (3) the Thatcher period, 1936 to 1955; and (4) the Selkirk-Conley-Justin period, 1956 to the present. Marquis, because of its earliness (in relation to Red Fife and Haynes Bluestem), escaped some rust damage. Ceres had resistance to some prevalent races of rust. Thatcher came into its own following the stem rust epidemics of 1935 and 1937. Selkirk came into prominence because of its resistance to 15B of stem rust. Conley and Justin represent a broader base of stem rust resistance and much improved quality.

Q. Is there anything special about wheat development in the spring wheat area?
A. Yes, there are two especially significant events: First, the breeding of Marquis wheat. In my mind this still stands out as the greatest achievement in wheat-breeding history. This variety, through its long domination, set the pattern for quality in the U.S.A. and Canada. Second, during the now approximately 60 years of wheat breeding in the spring wheat area and despite the heavy ravages of stem rust from time to time, no university, college, or experiment station has released a variety of inferior quality. This I feel is a remarkable tribute to the research workers along with members of the wheat trade who cooperated.

Q. How would you label the periods in wheat development in the eastern States?
A. The eastern half of the United States has gone through four major stages. I would call these (1) the colonial-expansion period, 1493 to 1910; (2) the Fultz-Fulcaster period, 1911 to 1934; (3) the Trumbull-Thorne-Vigo period, 1935 to 1954; and (4) the Knox period, 1955 to present.

Q. Why was the colonial expansion period important?
A. This was a period of active introduction of wheats from many countries followed by trials under diverse environments. The result was a sorting out of the best bulk lots for resowing and in this way the wheat industry was established in the eastern States.

Q. Didn't this present quite a hodge-podge of quality types?
A. Yes, but this was not serious, at least not in the early part of this period. Most of the wheats were soft to semihard and flour was of the general purpose type, ground on stone burs. After all, the main thing in those days was something to eat. High specialization of needs by bakers was no problem.

Q. Was the Fultz-Fulcaster period, 1911 to 1934, a miller-induced or farmer-induced development?
A. It was mostly due to farmer acceptance of two varieties--Fultz, a beardless soft, and Fulcaster, a bearded soft wheat. These varieties had good adaptation over a wide area and were grown on over a million acres annually from about 1915 to the early 1940's. Fultz was grown under many aliases (25 or more) and Fulcaster had over 50 other names. But the types were as described and the millers liked them. Fultz in the main corn belt area and Fulcaster in the Appalachian and Atlantic Coast states perhaps more than any other varieties were thought of when you mentioned "soft wheat" during this period.

Q. What is unique about the Trumbull-Thorne-Vigo period, 1935 to 1954?
A. These varieties, along with Seneca and several others, represent the first widespread impact of scientific wheat breeding on variety distribution in the eastern States. It also shows the results of a deliberate effort by plant breeders to release varieties of known good quality. Actually, Trumbull, a selection from Fultz, got its start in 1908 in Ohio. However, it was not until the mid 1930's that it exceeded a million acres per year. Largely upon the excellence of this variety, Ohio established its reputation for high-quality cake and cracker flours. The problem in new wheats was not alone to obtain higher yields, stiffer straw, and other characteristics of prime interest to the farmer, but also to protect the market by maintaining excellent quality.

Thorne was introduced in 1937 and received immediate and widespread acceptance, not only in Ohio but over much of the eastern soft wheat area. In 1949 it occupied almost two-thirds of the Ohio acreage and one-third of the total soft red winter wheat acreage of the nation. Thorne was accepted by the farmers because of its high yield, stiff straw, resistance to prevalent races of loose smut, and adaptability to combine harvesting. It became popular in spite of an inherent low weight per bushel and susceptibility to scab. Vigo, released from Indiana in 1946, was grown on 25 percent of the soft wheat acreage in 1954.

Q. I have heard that a Tri-state Soft Wheat Improvement Association was active during some of this period. What was this?
A. In 1929, the millers of Indiana, Michigan, and Ohio formed an association to work closely with experiment stations and grain dealers in the 3 states on wheat quality problems. They were more than advisory. They formulated premium and discount rates for soft wheat and gave added stability to quality of wheat in these states. While Ohio had had a quality laboratory since 1913, a special

5-year grant from the industry in 1929 gave strength to the program. A direct outgrowth of this effort was the establishment in 1936 of the USDA regional Eastern Soft Wheat Quality Laboratory at Wooster.

Q. This brings us to the present. The Knox variety must be something very special to cause you to name a period for it.
A. Yes, Knox marks a break with the old agronomic type of soft wheat that was tall, weak-strawed, and late in maturity. The new-type soft wheat is 7 to 10 days earlier and 8 to 10 inches shorter. While Knox is not as resistant to lodging as desired, other varieties of this new type do have superior lodging resistance and will stand well under high fertility management. New levels of leaf rust and Hessian fly resistance have been bred into these new varieties also, especially Monon, Reed, Redcoat, and Knox 62.

Q. How long have these wheats been "on the drawing boards," so to speak?
A. Twenty-seven years for Knox and Vermillion.

Q. Was quality testing a part of this development?
A. Yes, every step of the way. The lab at Wooster and the Iglehardt Bros. commercial lab in Indiana gave continuous help to the team of State-Federal breeders at Purdue University where this new type was hammered out. These wheats fit the high standards of the best-quality soft wheats.

Q. How would you label the periods in wheat development in the western States?
A. Because of the diversity of climate and soil, more than one type or class of wheat is grown in this region. Included are (1) soft white club, (2) soft white common, and (3) hard red and white wheats. However, because of time limitations we will consider variety developments in groups. The major periods in wheat development in the western region are (1) the Gold Rush Days, 1849 to 1909, (2) the Bluestem-Baart-Federations-Turkey-Hybrid 128 period, 1910 to 1944, (3) the Elgin-Elmar-Omar-and-Brevor period, 1945 to 1961; and (4) the Gaines period, 1962 to the present.

Q. What is unique about Hybrid 128?
A. Prior to 1909, wheat grown in the Pacific Northwest was essentially all spring wheat and about two-thirds was the club type. Farmers realized they could get higher yields if they planted in the fall except when winterkilling was a factor. Dr. Spillman at Washington State University realized the problem as early as 1894. He attempted to combine the cold resistance of Turkey and the shatter and lodging resistance of the club varieties. This was the first serious attempt to breed wheats of improved characteristics and for this work Spillman is recognized as one of the Re-Discoverers of Mendelism. He produced a whole series of "hybrid" wheats, one of which, Hybrid 128, was still a major variety in 1930 and it persisted until 1950.

Q. What was the major factor that spurred on the development of the later wheats?
A. Bunt (stinking smut) susceptibility.

Q. Which varieties have enjoyed the most popularity?
A. Elgin, released in 1935, occupied about 30 percent of the Pacific Northwest wheat in 1951. Because of Elgin's susceptibility to bunt, Elmar replaced Elgin.

Elmar in turn occupied about 50 percent of the total wheat acreage in 1956. New races of bunt attacked Elmar, and more resistance was built into Omar, released in 1955. Omar occupied about 67 percent of the total PNW wheat in 1960.

Q. Why place Gaines in a class by itself?
A. Tall straw along with bunt susceptibility has long been a major breeding problem in the PNW. Ways to reduce plant height have been sought which resulted in a breeding break-through in the production of a semi-dwarf common type which is extremely productive. This variety, named Gaines, in honor of Dr. E. F. Gaines, a former wheat breeder at Washington State University--and my major professor--also had satisfactory milling qualities. It is predicted by well-informed individuals that it might make up two-thirds of the 1964 crop in the PNW.

Q. Does this about cover the types by geographical area?
A. Not quite. The durum story is a fascinating one that commences with nondescript poor-quality, rust-susceptible, tall, weak-strawed varieties and progresses to the fine-quality Mindum, and more recently, the Langdon-Wells-Lakota varieties. Also, we left out the white winters of New York and Michigan--some of the finest-quality pastry wheat grown in the Nation. However, time does not permit more on this subject.

Q. Now, I want Dr. Barmore to tell us where the quality testing is actually done, and what the purposes are.
A. There are four quality laboratories supported primarily by Federal funds and administered by the Crops Research Division, Agricultural Research Service, USDA. Their primary purposes are as follows: (1) to determine and evaluate the milling and baking properties of new wheat selections developed or selected by wheat breeders in the U. S. and to do this on the earliest possible generations in the development of these new selections; (2) to improve current tests and develop new ones that will characterize wheat quality more accurately; (3) to investigate by every means possible the factors responsible for quality differences, as such information will make possible the greatest advances in breeding for improved quality.

The Eastern Soft Wheat Quality Laboratory is located in Wooster, Ohio, at the Ohio Agricultural Experiment Station and is concerned primarily with the soft red wheat breeding programs in Ohio, Indiana, Illinois, Missouri, North Carolina, and other eastern States, and in the soft white wheat programs in Michigan and New York. It was established in 1936.

The Hard Winter Wheat Quality Laboratory is located at Manhattan, Kansas, in the Department of Flour and Feed Milling Industries, Kansas State University, and as the name indicates is concerned primarily with the regional hard winter wheat breeding program in Kansas, Nebraska, Oklahoma, Colorado, Texas, and other States in this region. It was established in 1938.

The Western Wheat Quality Laboratory is located at Pullman, Washington, in the Department of Agricultural Chemistry, Washington State University. It is concerned with the western white and hard winter and spring wheat regional breeding programs in Washington, Oregon, Idaho, Utah, Montana, and to a minor extent in some of the other western States. It was established in 1946.

The Hard Spring and Durum Wheat Laboratory is the oldest of the four. It was established in 1926 in Washington, D.C. It was later moved to Beltsville, Maryland, and in May of this year was moved to Fargo, North Dakota. It is now located in the Department of Cereal Technology at North Dakota State University. It is concerned with the regional hard spring and durum breeding programs in North Dakota, South Dakota, Minnesota, Montana, and other North Central States.

There are wheat quality laboratories in many of the major wheat producing states supported wholly by State funds. One is here at the University of Nebraska; others are at Bozeman, Montana, St. Paul, Minnesota, Stillwater, Oklahoma, Aberdeen, Idaho, the Milling Department at Manhattan, Kansas, Cereal Technology Department at Fargo, North Dakota, and quite small labs at Logan, Utah, Ft. Collins, Colorado, and Arlington, Texas. I trust I have not missed any. These laboratories are concerned with State breeding work and State wheat quality problems.

Q. How do the Utilization Divisions of USDA at Peoria, Ill., and Albany, Calif., fit in here?
A. Their objectives are somewhat different and they do little or no service work. Their basic research--much of it--has direct bearing on our work and their new products or processes are of immediate interest to us in breeding suitable varieties.

Q. Paul Mattern operates a typical State laboratory. Paul, will you review the purpose you serve in breeding wheat for improved quality?
A. A quick review of a half century of activities in wheat research at Nebraska will set the stage for the current Nebraska program. Fifty years ago, virtually all of Nebraska's acreage was planted to Turkey wheat. Work started in the early 1920's resulted in the varieties Cheyenne and Nebred, which were released in 1933 and 1938, respectively. Pawnee followed in 1942 through joint State and USDA efforts at Nebraska and Kansas. By the early 1950's these three varieties accounted for most of our acreage.

There still were serious disease and insect threats to stable wheat production. The problems were not the same in all parts of the State either. Far-sighted individuals were responsible for a full-time State wheat breeding position in 1952 at the Nebraska College of Agriculture. Previously work on wheat was carried out on a part-time basis by already overloaded USDA and College of Agriculture staff. It is a tribute to these individuals that so much was accomplished under trying conditions. However, this increase in breeding greatly increased the number of potential new varieties that required quality tests. So rather than "fly blind" on quality, a local laboratory was established to work hand-in-hand with the breeders here.

Considerable support comes from many organizations throughout Nebraska. I hesitate to list names for fear of omission but the Nebraska Grain Improvement Association (celebrating its 25th Anniversary), more recently the Nebraska Wheat Growers Association, the Nebraska Wheat Commission, and the Agricultural Products Research Fund Committee have all figured prominently.

Samples examined in our lab come from the wheat breeding program in the Agronomy Department. Fertilizer and variety plot samples are sometimes used

from the Outstate Testing Program. Breeders' samples usually are not studied before the sixth generation, but in urgent cases, perhaps 100 grams could be spared from the F_3 plants; 400 grams from the F_4 plants. Usually 800 to 1000 grams from the F_5 plants are available (F_6 seed).

Wheat strains for conventional use are first examined for milling and mixing characteristics. The micro milling (Brabender Quadrumat) test helps to eliminate undesirable milling types. The mixograph is used to evaluate mixing characteristics. In some studies, e.g. the high-protein lines, there is a complete distribution of milling types resulting from crosses of hard and soft wheats.

The number one objective in wheat breeding at Nebraska is to produce varieties with stem rust resistance. A series of semi-dwarf wheats with stem rust resistance are among some of the most important material being evaluated for milling and baking quality. Fortunately, these lines have the high production of the semi-dwarfs along with adequate winter hardiness and leaf rust resistance. These materials represent wheat from F_5 plants.

Three new selections are now being considered in advanced testing for possible release. All have resistance to stem rust race 56--an old "enemy" which has given increasing trouble during the past four years. One selection has shown resistance to rust groups 17-29 on a world-wide basis. Another of these three has broad resistance to most wheat diseases and problems found in Nebraska. One new selection which has just been seeded for initial increase has resistance to race 15B but possibly not race 11E. The aim is to produce several bushels of this material. The main disadvantage is its late maturity and tallness--the quality appears good.

Q. What are the important quality factors sought?
A. Unfortunately, there are many and most are incompletely understood. Constituents contributing to the final dough properties in individual varieties are an important consideration. Dr. Eastin is carrying out work in our Laboratory to determine type and amount of various wheat proteins which are responsible for optimum dough properties.

Q. Why is so much emphasis placed on quality factors that are related to machine handling?
A. Nearly 4 times as much flour is used in bakeries in the U. S. as is used in the home (including mixes). This means that millers are delivering more flour than ever before that meets standards required for machine handling. In 1936, these two outlets for flour were about equal. Prior to that year family flour consumption exceeded bakery use. But not any more. This same trend has appeared in the quality of wheat and flour demanded in export markets, especially Europe.

A demonstration showing extreme differences in dough properties of an excellent bread wheat and a poorer type will point up the necessity for making the best selection from new crosses. Two doughs have been prepared as for normal baking. After a 3-hour fermentation period the doughs are run through the sheeter rolls and examined. The dough which has stretched out considerably would not be useful for a highly mechanized bakery--whereas, the other, exhibiting much greater strength, would be satisfactory.

Q. Now, we are to hear from Mark Barmore and Karl Finney about some work in the regional labs. Mark, why is regional testing needed?
A. Once a new wheat variety is released for production, it will spread to wherever it can be grown to advantage, yield or pricewise, compared to previously grown varieties. Consequently, prior to release by any State, it should be tested agronomically and quality wise for at least 3 years over its entire likely production area. This is the present practice and is carried out through the Uniform Regional Nurseries and other trials conducted voluntarily by agronomists in each of the four areas = Western, Hard Winter, Spring, and Eastern regions. The grain from these nurseries is submitted to the Federal laboratories for complete quality evaluations.

Q. Do these just happen to be grown or is there some direction to uniform testing?
A. A great amount of planning is involved but it is done so smoothly that it is scarcely noticed. In each region, one man serves as the coordinator. Traditionally, this has been a USDA agronomist. He works with his regional wheat improvement committee and of course with us in the regional labs.

Q. Is there a particular stage in variety development when you receive samples?
A. Samples of new selections are submitted to us at nearly every stage in their development--from a few grams available from single plants in the 3rd generation to bushel lots from commercial fields. The first tests applied consist of micro milling followed by micro sedimentation and protein content of the good milling types. These are followed by 1000 to 2400 gram millings, cake and cookie baking, viscosity, and other physical tests for pastry types and bread baking, sedimentation, mixing, and other physical tests on the hard wheat types. As many as 11 different observations are made on wheat and 16 on the flour, depending on the amount of wheat and in turn the amount of flour that is available. The properties of new selections must be compared with comparably grown current commercial varieties. If they have equal or superior properties, they will have good quality, but if not, they are considered to have poor quality. By means of punch cards and automatic computers, we have described the relative properties of common commercial varieties and by comparison of the properties of new selections with these, we can easily illustrate their relative quality.

Q. What new important developments have been made at Pullman?
A. We developed a micro sedimentation method to characterize flour properties of micro-milled selections. We have contributed to the isolation of factors responsible for pastry flour quality and are progressing on the chemistry of flour bleaching by chlorine. We have studied the molecular characteristics of flour constituents. We developed a new rapid dye method of determining protein content of wheat and other agricultural products.

Q. Mr. Finney, in addition to regional testing, what else do the regional Federal laboratories do?
A. Basic research. Because some States have no quality labs and the ones that do are to varying degrees limited by space, funds, and personnel, relatively little basic research is carried on although this is not true of all State labs. It is just as important to do basic research today as it was 100 years ago when our Nation's land-grant college system and Department of Agriculture were established. Where would agriculture be today if man had been content with the wheat varieties and crude implements used in 1862?

Q. What phases of basic research are conducted in your laboratory?
A. The following represent studies that we believe are essential to a healthy and progressive testing program: (1) research on methods of determining, factors affecting, and constituents responsible for properties or characteristics constituting quality; (2) development of new tools and approaches for studying quality; (3) research on the physiology of the wheat plant relative to wheat quality; (4) these three phases of research are focused on the basic problem of determining the physical, chemical, biochemical, and quantitative differences between the constituents of good and poor quality varieties. As we obtain these answers, we will be able to devise simpler, improved, and more basic methods for determining the wheat and flour characteristics constituting quality.

Q. You mentioned research on development of tools for studying quality. What sort of tools?
A. For one, fractionating and reconstituting techniques which literally mean taking a flour apart and then putting it back together. For example, it has been demonstrated that hard wheat flour can be separated into starch, gluten protein, and water-soluble fractions. Each of these can be fractionated further and the fractions from good and poor quality wheat varieties interchanged one at a time, recombined in their original proportions, and then baked into bread. Differences in loaf volume potentialities of good and poor quality wheats are entirely accounted for by differences in their gluten protein fractions.

These data show that the relation between protein content and loaf volume is substantially linear within a variety and between the limits of 7 or 8 to at least 20 percent protein. Therefore, the regression coefficient, or loaf volume correction factor for protein content, can be applied within these limits. Below 7 percent protein the relation is definitely curvilinear, all curves meeting at 0 percent protein and about 275-cc. loaf volume. Thus at 0 percent protein content, the volume potentialities of all varieties are equal.

The data show in addition that the regression of loaf volume on protein content is different for different varieties and appears to be a function of the loaf volume that may be produced by a variety at any arbitrary protein level within the range of linearity. Therefore one can determine the factor for correcting the loaf volume of a given sample to a constant protein basis simply from a knowledge of its protein content and loaf volume, thereby eliminating the need for loaf-volume data at several protein levels of the variety or sample in question.

Q. What are the nature and significance of research on the physiology of the wheat plant in relation to wheat and flour quality?
A. As early as 21 to 22 days before wheat is ripe, it is known that 85 to 95 percent of the eventual total quantity of Kjeldahl protein has been laid down in the wheat grain. However, that protein is only somewhat over 50 percent as good as that in ripe grain; but, as early as about 12 days before ripe, the protein is actually about 10 percent better than gluten protein from ripe wheat so far as gas retention and physical dough properties are concerned. A similar curve is obtained when test weight is plotted against stage of maturity, optimum test weight being obtained 4 to 8 days before ripe. Thus, the wheat plant is physiologically mature several days before it is ripe according to prevailing concepts. These data indicate that before the advent of the combine, wheat that was cut and shocked several days before ripe actually was superior.

Q. Are there any practical implications from these studies?
A. Not at present. There may be suitable equipment in the future for drying wheat heads with their straw so that cutting and threshing can be carried out a week to 10 days before the grain normally would be ripe. In this way the farmer, miller, and baker could enjoy wheats with higher test weights (1-5 lb./bu.) and normal milling properties, and flours having superior loaf volume potentialities, higher dough absorptions, better dough handling properties, and more mixing tolerance. If wheat crops could be harvested prematurely, many would escape partial or total damage due to hail, wind, rain, and high temperatures.

Q. Do you have any other tricks to study basic quality?
A. A rather unique tool involves foliar or leaf spraying of the wheat plant. The root system does a fairly good job of regulating the uptake of many important elements, such as the sulfur that occurs in the amino acids cystine and cysteine of gluten protein, which is associated with such important dough properties as degree of extensibility and oxidation requirement. Foliar spraying, on the other hand, permits the uptake, translocation, and incorporation of important elements in the gluten protein complex in concentrations much higher than normally occur and, in addition, possibly permits the incorporation of specific nitrogen groups in the protein molecule.

For example, sulfur and nitrogen in the form of thiourea, N,N'-diethylthiourea, and ethylene thiourea were applied to the leaves of the wheat plant. Protein content of the flour was increased by 2.5 to 4.5 percent. Total sulfur contents of the flours were increased about 20 percent above those for flours milled from wheats that were sprayed with ammonium nitrate and such nonsulfur-containing ureas as N,N'-dimethylurea, N,N-diethylurea, and urea.

The baking properties of flour from thiourea and N,N'-diethylthiourea-treated plants were normal; whereas, loaf volume potentialities and mixing properties for flour milled from wheat sprayed with ethylene thiourea were only about 40 percent of normal.

With foliar spraying as a tool, it is hoped that the relation of specific chemical elements or groups to variations in flour properties can be ascertained in an attempt to learn why the protein quality of some varieties of wheat is good and that of others is poor.

Q. Tell us how your laboratory program is related to breeding new varieties?
A. Each year after harvest, a number of plant breeders submit agronomically promising new progenies of wheat for evaluation of milling and baking quality prior to planting. The number of samples submitted by each will vary from a few to as many as a hundred. Although there is a limit to the number of samples that can be tested in time for planting, it has not been necessary to limit the number each breeder can submit because of the discretion they have exercised in the past. If a plant breeder submits a relatively large number of early generation progenies for evaluation, usually only a few of them will prove to be worthy of future testing. Several hundred additional wheat progenies are submitted by plant breeders throughout the Great Plains for testing and evaluating during the late fall, winter, and spring months.

It is noteworthy that all commercial varieties, new releases, and other agronomically promising progenies submitted for testing are characterized with

respect to the important wheat and flour properties constituting quality and thereafter evaluated for their suitability for bread production in much the same way mentioned by Dr. Barmore.

Loaf volume is evaluated against known varieties after correction or adjustment to a suitable protein level. Loaf volume increases with increasing protein content within a variety, and the regression lines for different wheat varieties form a fan-shaped family of lines. The vertical difference between any two regression lines represents the difference in the gas retention (quality) of the gluten protein. Mixing time and tolerance of varieties of wheat are determined from mixograms.

Q. Earlier in your remarks, you stated that one phase of research in the Hard Winter Wheat Laboratory was aimed at testing small samples of early generation wheat progenies in larger numbers. What has been accomplished along this line?
A. To effectively evaluate small samples of wheat requires research on methods and techniques of breeding as well as determining quality characteristics. Obviously there is a limit to the number of samples a wheat breeder can handle each year; but he can handle more samples in the field than we can in the laboratory. Two lines of study have contributed to at least a partial resolution of the problems.

First, we have been handling the quality testing aspects of research on an F_2 progeny test proposed by Dr. E. G. Heyne, plant breeder at Kansas State University. Using this technique, about 150 grams of flour can be obtained from F_2 progeny lines in the F_4 generation. Certain physical and chemical tests on the flour can be used to predict the milling and baking quality of pure line selections made later in F_6 or F_7. Each F_2 bulk found to be of good quality when grown in F_4 potentially represents material from which an infinite number of good-baking-quality selections can be made. Additional quality tests need not be conducted until most of the breeding lines have been eliminated on the basis of agronomic traits. Thus the F_2 progeny test, in contrast to the pure line selection method, greatly increases the potential number of good-quality pure line selections that the plant breeder can have available for agronomic study.

Second, we have a micro milling setup that represents a material improvement over anything previously used in our laboratories, and, I believe, over any other hard wheat micro milling setup presently available.

Q. Time does not permit detailed discussion of work done in the Hard Spring and Durum Laboratory at Fargo, or in the Eastern Soft Wheat Laboratory at Wooster. Their missions are similar to those of the other labs but are uniquely adapted to the variety problems and quality requirements of significance in those regions. I believe each laboratory collaborates with the trade. Is this true, Karl? And Mark?
A. Yes, there is liaison between the Regional Hard Winter Wheat Laboratory and the trade through the Hard Winter Wheat Quality Advisory Council, the executive committee of which is composed of a number of individuals from the milling, baking, and grain industries. Each year Federal and State laboratories participate as collaborators with commercial milling and baking laboratories in testing and evaluating prospective new wheat varieties compared to suitable standards. Results and evaluations for prospective new releases harvested in 1962 will be discussed at a formal meeting later this winter.

The Crop Quality Council, Minneapolis, conducts quality trials on new varieties of interest in the north-central region. They will have their next formal meeting January 29, 1963.

Both the Eastern Soft and the Western Wheat Quality Laboratories have advisory committees made up of milling industry millers and chemists that meet annually with the staffs to discuss in detail their programs and work. The members are also available at any time for consultation. Commercial scale milling tests have been conducted on new varieties prior to release, and in every case the results have agreed with the predictions made from quality laboratory results.

Q. Dr. Barmore, how do you determine whether a variety will mill satisfactorily?
A. Samples with poor milling characteristics have low yields of flour, or the ash content is high, or they are difficult to sift and must be milled at a reduced rate. This appears to be due to the shape of the flour particles--the poor millers break into ragged or irregular shapes in contrast to good milling types which break into more nearly rectangular particles. This ragged condition appears, thanks to the fine work of the USDA utilization labs at Albany, California, and Peoria, Illinois, to be due to thick cell walls in the endosperm of the wheat kernel. This condition apparently is intensified near the bran, resulting in more difficulty in separating the flour from the bran layers in this region. This property of the poor milling types is the basis for our micro milling test.

Q. Karl, with what environmental hazards are you concerned?
A. Both climatological and disease hazards. High temperatures and low relative humidities during the last 15 days before harvest are very important climatic factors. Loaf volume, crumb grain, water absorption, mixing time, and dough handling properties of hard wheats usually are impaired to varying degrees. Loaf volume subnormality increases, in general, as the sum of degrees above 90°F. increases during the last 15 days of the fruiting period.

Q. Do you know the reasons for the spread or range of loaf volume deviation for a given amount of high temperature above 90°F.?
A. Spreading is accounted for by differences in (1) variety, (2) flour protein content, (3) physical and chemical condition of the soil, and (4) relative humidity. Varieties with the longer mixing requirements are more tolerant or resistant to the detrimental effects of high temperatures during fruiting. It is the gluten protein that is damaged. Thus, the higher the sample protein, the greater the deviation from normal or expected.

Damage to loaf volume was highly correlated with the variable amount of observed injury to the plants. Data obtained in recent years show that high temperatures above 90°F. are not likely to impair baking properties when relative humidities above about 30 percent prevail. Hard red spring wheats are affected in a similar manner, but usually to a smaller degree. In the absence of high temperatures during the last two weeks before harvest, other environmental factors such as rainfall and the chemical and physical composition of the soil appear to have relatively minor effects on flour properties (quality) except for protein content.

Q. What are examples of the disease hazards?
A. Soil-borne and wheat-streak mosaics, rust, and scab. Samples of wheat

infected with either soil-borne or wheat-streak mosaic viruses had (1) test weights, flour yields, and flour ashes that were inferior to the corresponding controls, (2) protein quality and mixing properties that were equal to the controls, and (3) other baking properties, particularly water absorption, protein content, and "as received" loaf volume, that were distinctly superior to those for the controls.

The effect of scab on wheat and flour quality, however, presents an entirely different picture. The internal characteristics and relative volumes of loaves of bread baked from a normal hard-wheat flour, a 100 percent scabby wheat flour (made from hand selected kernels) and their blends containing 10, 20, and 30 percent of scabby wheat flour have been compared.

Loaf volume and internal characteristics of bread baked from flour milled from the normal portion of the sample were normal in every respect, whereas those for the flour milled from the 100 percent scabby (white) sample of wheat were unbelievably poor. Crumb grain was heavy and soggy as in a poor-quality corn bread, and the loaf volume of 388 cc. was only slightly larger than that contributed by the starch and other components of a flour containing no protein.

Gas productions of the normal and scabby samples were normal and equal through and beyond four hours of fermentation. Thus, the extremely poor loaf volume and crumb grain of the flour from 100 percent scabby wheat was not due to insufficient gas production.

Proteolytic activity indicated that the brown sample was about 16 days preripe, whereas the scabby (white) sample represented a stage of development of about 22 days preripe. In addition, the scabby wheat contained about twice the water-soluble protein content of the brown wheat. These data for proteolytic activity and water-soluble nitrogen tie in consistently with previous studies concerning the chemical and baking properties of wheat harvested at various stages of maturity. Accordingly, it appears that the 100 percent scabby wheat simply was killed at a sufficiently early stage of maturity (22 days before ripe) before appreciable gluten protein synthesis had occurred, thereby accounting for the inability of the protein in the flour milled from 100 percent scabby wheat to retain the carbon dioxide produced during fermentation. Previous studies have shown that baking characteristics usually are about normal (compared to ripe samples) as early as 16 days preripe, and above normal 10 to 14 days preripe.

Rust often causes shriveling of grain, which results in poor milling properties. The effect of rust on baking quality varies with the time and degree of infection and is being studied in our laboratories.

Q. Do any of you use the sedimentation test in breeding for bread quality?
A. We believe the sedimentation test is useful in breeding for bread quality. We have used it in a modified form for the past 10 years. It helps to characterize varieties and new selections. We know the test is being used in a number of foreign countries. As a rule. we use it in conjunction with other prediction tests. (Barmore)

In regard to the usefulness of the sedimentation test, we have no final answer yet. We are extending our work with the remix baking test on the annual

wheat show samples and collaborative milling and baking samples and hope for an answer this year. We are a bit concerned about the inconsistencies seen in sedimentation values from our wheats. (Mattern)

The question suggests to me the following facts and discussion: Good quality or strong type wheats must be considered from both the breeding and commercial standpoints. A genetically good quality or strong wheat is not a good quality or strong wheat commercially unless it has a sufficient quantity of protein. Thus we could grow genetically strong hard winter wheats throughout all of the Great Plains, but if protein content was low, the wheats would be commercially weak or of poor quality simply because protein content was a limiting factor. Thus the one thing that would improve materially the commercial quality or strength of our hard winter wheat crop would be to adopt cultural practices or breed high-protein varieties that would raise the protein level of wheat by at least 1 and preferably 2 percent. Any cost to the farmer, of course, would have to be returned in the form of materially greater premiums for protein content. (Finney)

Q. Paul, you have some special genetic work in Nebraska involving the factors that individual chromosomes carry. How are you coming along?
A. Several avenues of work are being investigated for the purpose of identifying superior chromosomes for various facets of wheat quality. Dr. Rosalind Morris and her co-workers in cytogenetics, through special breeding materials (aneuploids), have produced a special series of 21 seed stocks. These 21 samples have identical composition in 20 pairs of chromosomes. However, the remaining pair represents individual chromosome pairs from the Cheyenne wheat variety.

Our work is just getting under way but we are all enthusiastic about the potential. The results have not been published; however, the following general statements may be of interest. For example, an individual chromosome appears responsible for the milling properties of a hard winter wheat. Interestingly, a number of different chromosomes appear to modify mixing characteristics--which explains problems encountered in transferring Cheyenne mixing characteristics in breeding work. Gliadin components also differ considerably on the basis of a single chromosome pair.

In order to speed up this type of work, Dr. Johnson and Dr. Schmidt in another separate study have made crosses with Wichita monosomics and disomics for all the individual chromosomes to Omaha, Bison, and Warrior varieties. Work with crosses to Cheyenne will be completed this year. Bulk material from these crosses will be examined for contributions of specifically substituted individual chromosomes.

Q. We hear about the continuous system for making bread. How will this affect the kind of wheat we should breed? Karl?
A. Opinions of leading commercial milling firms have indicated that our present commercial hard winter and hard red spring wheat varieties are suitable for the continuous dough process.

Data obtained in the Hard Winter Wheat Quality Laboratory show that the better quality or stronger type varieties with medium to medium-long mixing

requirements usually had better crumb grains and loaf volumes than the poorer-quality varieties with relatively short mix times when employing either of two pre-ferment baking formulas used in continuous bread-making. Thus, there is a reasonable amount of evidence to indicate that our present commercial varieties of hard winter wheat are entirely suitable for the continuous bread-making process.

Q. Why not breed some wheats strictly for feed and forget about quality, and breed others for high quality to serve special markets?
A. Prior to releasing or even breeding a feed wheat, we must have some means of identifying it so that it can be kept separate from milling wheat. One breeder in our region has developed a blue color in the grain. We must also have a pricing structure to handle the problem if feed wheat is to be a part of the wheat crop. We already have too much feed wheat that doesn't get fed to animals. (Barmore)

In general, the "good quality" limitation placed on high yielding varieties has caused the breeder no more difficulty than any other complex genetic trait. The fact that good quality and good yield have been combined successfully in every region of the U. S. seems proof to me that this compromise on quality is not necessary. However, quality testing is expensive and it slows the rate of progress. As wheat enters more industrial and speciality-food uses, research on producing the right kind of wheat, thereby reducing the amount of chemical modification needed, will take on new significance. For example, emphasis on breeding for new high levels of protein perhaps should have a counterpart program on breeding varieties extremely low in protein for some market outlets. (Schlehuber)

Q. We have heard about air classification. Which types of wheat are more easily classified?
A. Normally softer endosperm types produce flours with smaller particle sizes (more proteinaceous wedges and free starch granules). Processing of softer wheat flours would be more efficient since less regrinding would be required.

Q. How does Nebraska fit into such a picture as far as hardness types are concerned?
A. This explains part of our interest in this area of research, since our Nebraska varieties tend to be harder endosperm types. Because new varieties are not produced overnight, we are trying to anticipate what we would have to do to compete in a wheat industry in which milling practices involved more air classification techniques.

Q. What are some of your research findings on varieties with respect to their efficiencies in air classification?
A. Our first attempt was to examine Nebraska varieties using a system which produced a pastry flour and a bread blend (composed of the high-protein fraction added back to the coarse residue). Several general observations may be of interest. The amount of the high-protein fraction varies from 5.5 to 13.2 percent at rather comparable protein levels of about 19 percent. The pastry flour yields ranged from 20 to 35 percent (an important factor with higher-valued pastry flours). The resulting bread blends were at adequate protein levels. It appears that wheat varieties play an important role in air classification.

Q. What is the relation between quantity and quality of the products?
A. In addition to the inherent air classification yield potentials, we have inherent quality factors of the products. Curves produced from bread blends show that increasing the protein content with protein concentrate from the same flour may not help the mixing tolerance. Specific protein quality types will still be required and will depend on end uses.

Q. What are some conclusions on varieties based on work so far?
A. Selections can be made for dual-quality types if a transition period comes in the milling area. These would be wheats having excellent conventional milling and baking properties. In addition they would air classify efficiently and produce acceptable end use products. If two new varieties were equally acceptable but one gave better flexibility with air classification, the choice should be obvious if air classification might be used by processors.

CONCLUDING REMARKS

Howard Morton
Director of Utilization Research, Great Plains Wheat, Inc.

During the last three days we, from our varied disciplines, have had an opportunity to listen to and participate in the presentations and discussions on production, utilization, nutrition, and marketing research. I am sure some questions have been answered and many new ones brought to light. We are now all the more cognizant of the many complex problems in our wheat industry.

This conference has, I am sure, pointed out the interdependent relationships of wheat production and its utilization. Subsequent meetings in this series will show further expansion in research, the objective of which is to enhance the position of the wheat industry. We certainly appreciate the sincere efforts of scientists for their never-ending activity in the field of research.

Proceedings of this conference will be published and distributed to those registered here and to others interested. In addition, proceedings of an earlier meeting, the Conference on the Role of Wheat in the World's Food Supply, are available from the Western Utilization Research and Development Division. There has been widespread interest in that meeting, which was a forerunner of the meeting here in Lincoln.

I thank all of you for your intense interest, enthusiasm, and support of this the first annual National Conference on Wheat Utilization Research, and look forward to seeing you at the next one, which will be held at the Northern Utilization Research Laboratory in Peoria, Illinois.

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